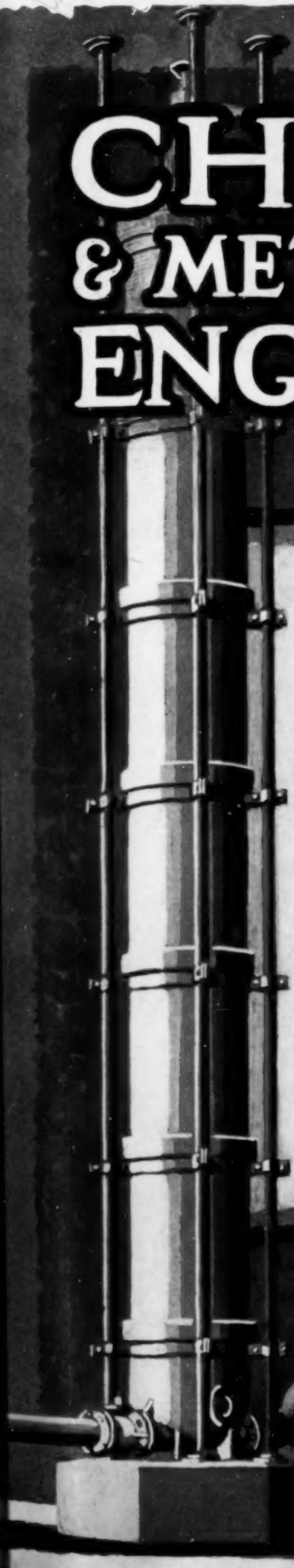
, March 1, 1919 McGraw-Hill Company, Inc. Vol. XX, No. 5 25c a copy

CHEMICAL & METALLURGICAL ENGINEERING



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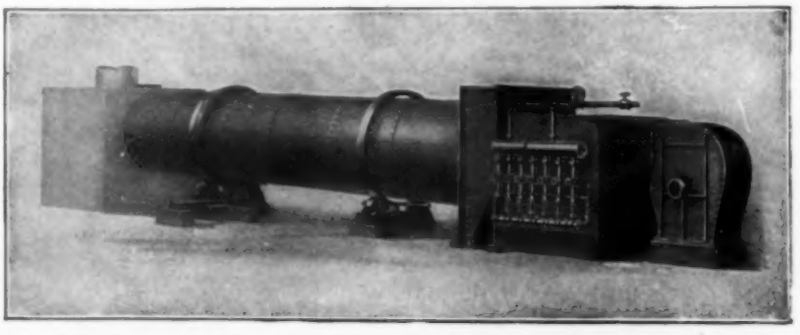

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Published SEMI-MONTHLY *on the* FIRST *and* FIFTEENTH *of each month*

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

McGRAW-HILL COMPANY, INC.
Tenth Avenue at 36th Street
NEW YORK

JAMES H. McGRAW, President
ARTHUR J. BALDWIN, Vice President E. J. MEHREN Vice President
J. MALCOLM MUIR, Vice President EDWARD CALDWELL, Treasurer
JAMES H. McGRAW, JR., Secretary

TELEPHONE 2840 Greeley CABLE ADDRESS, Machinist, New York

WASHINGTON, Colorado Bldg. SALT LAKE CITY, Newhouse Bldg.
CHICAGO, Old Colony Bldg. PHILADELPHIA, Real Estate Trust Bldg
SAN FRANCISCO, Rialto Bldg. CLEVELAND, Leader-News Bldg.
LONDON, 6 Bouverie St., E. C. 4.

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Yearly Subscription price for United States, Mexico and United States dependencies, $3; all other countries, $4. Single Copy, 25c.

When change of address is ordered, the NEW and the OLD addresses must be given. Notice must be received at least 10 days before change takes place. No back copies for more than three months.

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Circulation of this issue 12,250 copies

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Post-War Meetings of Scientific Societies

WE NOTE the approaching sessions of two important conventions which have special interest for chemists and electrochemists. The American Electrochemical Society will meet in New York, April 3-5, and will make a special feature of papers on subjects that were taboo during the war, but on which information has now been released. Considering electrochemistry's notable contributions to modern warfare, we may look for announcements of intense interest. In the following week, April 8-11, the American Chemical Society will meet at Buffalo and will give special consideration to needed Congressional legislation with relation to the chemical industry. Both meetings will reward attendance by members of the profession.

Validation of Informal Contracts

THERE is prospect of immediate legislation that will afford relief to those who were engaged in the production of munitions of war when armistice was declared, and who found themselves embarrassed by the non-existence of formally executed contracts with the Government. Although Government officials recognized that many of these agreements were *bona fide*, the Comptroller of the Treasury refused to recognize the obligation and the contracts were outlawed on technical grounds. Representations were immediately made to Congress, and several bills were introduced. The House and Senate passed different bills, but conferees have drafted a new bill which they will recommend for passage. According to its terms, claims must be presented before June 30, 1919. The Secretary of War will be authorized to settle obligations for war supplies, and the Secretary of the Interior will be authorized to discharge agreements, express or implied, with those producers of ores named in the so-called War Minerals Bill, the production of which was urged or demanded by Governmental agencies.

Abolish Duty-Free Imports of Chemicals

EACH succeeding National Exposition of Chemical Industries has emphasized the growing independence of our country in chemical matters, until the idea has become fairly well grounded. If the familiar German label has not become abhorrent for any other reason, its discovery on chemicals used by the enemy in gas warfare should make it an outlaw in respectable laboratories. We have only ourselves to blame, however, for the inculcation of the idea that Germany alone could supply our laboratory needs, and particularly those of

our schools, colleges and universities. By Congressional legislation we have permitted educational and similar institutions to import chemicals and apparatus duty-free, until the number of such availing themselves of this privilege in 1914 was probably in the neighborhood of 10,000! Imports of this class were valued at $572,726 in the fiscal year 1913, and at $704,496 in 1914. We believe we voice the patriotic sentiment of every educational institution when we say that Congress should repeal that clause of the tariff which permits the duty-free importation of chemicals and apparatus, and thus encourage American industry in its willing efforts to meet our own needs. It may cost more money for a time, but the additional expense will be welcome and we can find solace in the knowledge that we can shortly build up a million-dollar industry where little or nothing existed before. American manufacturers have shown their ability and their readiness immediately to supply our schools with American products. American teachers undoubtedly are ready and willing to patronize them. It remains only for Congress to act, and that should be done speedily before German agents begin to reconstruct their lost markets.

Favorable Prospect for Water-Power Legislation

AT THE hour of going to press advices from Washington announce the agreement of House and Senate conferees on provisions for water-power legislation. It is expected that a report will be made to both bodies on or before March 1, and unless there is a filibuster against the bill there is every prospect that it will be passed. The principal provisions do not differ greatly from those previously reported in CHEMICAL & METALLURGICAL ENGINEERING. The control of water-power development is vested in a committee of the Secretaries of the Interior, War and Agriculture. The definition of net investment with relation to recapture of water-power projects by the Government at the end of a fifty-year license period remains practically unaltered. If we are so fortunate as to secure a water-power bill from this session of Congress it will constitute one of the most important steps that could be taken toward reconstruction along sound and substantial lines.

Progress in Zinc Smelting Awaits Impulse From Metallurgists

EVERY zinc metallurgist, worthy of the name, has schemes similar to those of Mr. CHOATE presented elsewhere in this issue, and can hardly wait for the opportune moment when some of the more apparent drawbacks to the present industry can be replaced by more efficient and more modern methods. However, they are almost invariably entirely occupied in keeping the existing plants going, and therefore most of the plans unfortunately remain "dreams."

Mr. CHOATE'S many proposals are worthy of careful consideration and free discussion, but the best results would necessitate the disclosure of practical experiences from a very large number of zinc metallurgists. Such a discussion would be of enormous value indeed! Obvious impediments have so far stood in the way. Thus, in practically all companies the capital is represented by non-technical men who veto the exchange of confidences between the technical staffs. These directors have not yet realized that their mistaken secretiveness excludes ten new ideas from their organization for each quasi-trade secret impounded, while on the other hand the "open door" has done much to advance such as the Phelps-Dodge Corporation to the forefront of copper smelting. Granted that the first duty of the individual operators is to their respective employers, still they can take the first move toward turning the zinc industry from the approaching cul de sac by continually bombarding the management with the idea that at the very worst an interchange of ideas could not make the situation any more difficult.

Advance in zinc smelting has been slow not because the metallurgists have been unwilling or unable to improve the practice—a frequent reproach—but because the large appropriations necessary for experimentation have been denied them. Zinc plants are still built in comparatively small units, the tonnage treated is greatly inferior to that of smelters producing the other common metals, and large capital investments have ordinarily been absent. The one exception to this rule is the Anaconda Copper Mining Co., which by unstinted expenditure of funds and talent accomplished very excellent results along an entirely new and most difficult line of metallurgy, namely, by the electrolysis of sulphate solution. Under similar circumstances others in the profession could no doubt accomplish similar results, and along different lines.

Every one feels the pressing need; the favorable moment has arrived; metallurgists should embrace it to force, if need be, halting recognition of their latent capabilities.

Hard Times For Inventors

THE INCOME tax certainly does pinch a fat pocketbook! It is a fashion of the day, and there is no use protesting; but its probably constitutional, although approximately confiscatory, features in relation to large incomes are likely to slow down the machinery of industrial progress. Every new idea must pass through a speculative phase before it becomes established. The man of limited income cannot afford to speculate. The consensus of human experience is against it. If he has a little something set aside for a rainy day or to provide for old age, he should not play fast and loose with it. With all our reforms and changes in public policy we have not yet reached the point at which we discourage thrift.

Rich men can afford to speculate. They set aside what they are willing to lose, and "take fliers" with it. It is by means of such excess wealth that most new enterprises have been started, and these make for competition, as well as for industrial progress, while they bring down prices in the end. We are not praising rich men, or making any plea for an increase in millionaires; we are merely stating the fact that new enterprises are usually started by savings of the well-to-do; by means of funds that are or should be available for speculation.

Corporations may speculate on new methods, processes and materials within reason. The means for this is taken from research funds. But corporations are slow to change factory practice, and we could fill all our pages with testimonials taken from inventors of

the day to prove that novelties and improvements are hard to get through the front door of industry. It is generally admitted to be wholly useless to offer patents of any kind to certain corporations. We are not complaining; we are merely recording the experiences of the past. As instances of the difficulty of getting even great inventions over the speculative stage we may mention HALL with his aluminium process, or HERMAN FRASCH'S conquest of the sulphur problem in the Gulf States. We should probably still be without sulphur if it had not been for H. McK. TWOMBLY, MRS. HEWITT, and a few others who took a flier on backing the Frasch process.

Banks are not allowed to speculate, but banking institutions by their affiliations with persons of wealth can offer them the opportunity to speculate of their own free will. That is the way in which great promotions have been effected. It comes right back to the rich men again.

Although hope may spring eternal in the human breast, few of us like a treadmill. The incentive to make money only to see it taken away again by taxation is, somehow, not very strong. Possibly it should be great and patriotic, but it is not so regarded. Nobody goes up to the tax-collector's office joyfully and with a brass band. The whole proceeding has never yet acquired charm. Therefore rich men are growing wary of taking fliers in new enterprises, on the ground that, if they lose, their money will be gone, and if they win their profits will be taken away by taxes. They are less inclined toward new things that look good. And the inventor is having a hard time of it.

Iron and Steel
Production in 1917

APART from the pig iron and steel rail statistics for 1917, the industry's production statistics for that year are belated and have appeared only in the past fortnight, the delay, of course, being due to the fact that there was more important work on hand, by way of winning the war. Despite their age the figures are quite interesting.

The total production of steel ingots in 1917 was 43,619,200 gross tons, in close keeping with estimates already made and comparing with 41,401,917 tons in 1916, previously the record year. Production in 1906 was 22,624,431 tons, or more than 3,000,000 tons in excess of the best previous output, so that production almost doubled in eleven years. There was more than a doubling from 1905 to 1916.

The production of steel castings in 1917 was 1,441,407 tons, showing an increase of 5 per cent over 1916, previously the record year. From 1906 to 1917 the production of steel castings practically doubled, yet that was really no remarkable record, considering the enormous field of iron castings from which the steel casting could draw if, as some of its votaries used to think, it was going to displace the iron casting in so many uses. Beyond question the steel casting serves an extremely useful purpose in many connections, but the uses do not run into tonnage to the extent that is expected by many.

What is commonly called for statistical purposes "the production of steel" was 45,060,607 tons in 1917, that being the sum of the production of steel ingots and of steel castings. So far as its weight goes, the steel casting is very nearly a finished product, but it is not so with the steel ingot. That is merely a form of material which for intelligent and economical operation of works it is necessary to weigh. Ingots are not an article of commerce to any extent, even between works. There is a large reduction in weight from the ingot to the finished rolled steel, due to the production of scale and of scrap, materials that are reclaimed, the one by the blast furnace, the other by the open-hearth furnace.

The production of finished rolled steel, on the other hand, represents substantially commercial steel, material that is bought and sold and put into use, with relatively little loss of weight. The statistics of rolled steel measure the material after its last hot rolling and after the necessary shearing. Thus sheet bars are not reported as rolled steel, the rolled material reported being black sheets, black plates for tinning and tin mill specialties. Pipe, on the other hand, is reported separately, while the skelp in included as finished rolled steel. Rods, again, are reported rather than billets or drawn wire.

The production of finished rolled steel in 1917 was 31,199,943 gross tons, against 32,380,389 tons in 1916. The rolled steel for 1917 plus the steel castings makes a total of 32,600,000 gross tons, which in a commercial sense might be considered the product of the steel industry, with some allowances for loss in wire drawing, pipe making, etc.

During the major portion of 1917 the United States was in the war and quite actively in it so far as preparation was concerned, while the industry was supplying much material for the Allies. Nevertheless, the analysis of total output of rolled steel, as rails, rods, plates, hoops, etc., diverged but little from the usual or normal distribution. Taking rolled iron and steel together, there having been 1,867,757 tons of iron rolled, there was a total of 33,067,700 tons. Of this, 3,110,000 tons was structural shapes, about the normal proportion, while 2,944,161 tons was rails, also not much out of line. The exceptionally heavy production of wire rods in 1916, however, was not repeated, wire rod production dropping from 3,518,746 tons in 1916 to 3,137,138 tons in 1917.

It may seem a trifle strange to those not addicted to statistics that there should be a larger tonnage of wire rods produced than of rails, but this has been the case for several years. Wire is ubiquitous, like the tin can, and indeed there was 1,512,146 tons of tin and terne plate made in 1917, or more than half the rail tonnage. The weight of steel in a mile of track laid in 100-pound rails is about equal to the weight of tin plate required to make 1,400,000 two-pound tin cans, but the tin can is more an article of individual consumption, and thus is necessarily very numerous.

An interesting item is that the production of sheared plates, ¼-inch and heavier, increased from 1,865,642 gross tons in 1916 to 2,461,938 tons in 1917, a gain of 596,296 tons. This was due to harder driving rather than to increased capacity, as most of the large plate mills lately built did not come in until 1918 and some of them indeed contributed but little even to that year's production.

Readers' Views and Comments

The Present Status of Oil Shales

To the Editor of Chemical & Metallurgical Engineering

SIR:—On page 25 of your Jan. 1 issue you publish an article headed "The Present Status of Oil Shales." Therein you say, "while the Scottish shale industry exists by virtue of the ammonia recovered as a by-product." Some years ago this statement would have been a true representation of the case, but it is true no longer, and your making it now may be the cause of much waste of capital. You use this statement as the basis of an argument, by which you endeavor to encourage the adoption in the States of what is known as the Scotch retort, but which I, in order that no misunderstanding may arise, have renamed the Scotch dual purpose retort.

I fear your study of the history of the oil shale industry in Scotland and of the evolution of the retort in Scotland and elsewhere has not been as thorough and complete as is desirable. The designing and construction of the Scotch dual purpose retort were the result of certain local conditions that have since very largely ceased to exist in Scotland, and which do not exist in any other locality where oil shales are found. The dual purpose retort was the result of these conditions, and credit is due the Scotch operators for perfecting the retort to suit the conditions they had then to meet. But for countries or for localities where those conditions are not present it would not be wise to advise the adoption of such an expensive retort, knowing that more expense would have to be incurred to adapt it to the local conditions existent.

Before any one gives advice, before any one decides what retort to operate, it would be well to understand what were the special conditions that evolved the Scotch dual purpose retort. The conditions were as follows: The sale price of crude oil was very low, away under to-day's prices and under the prices that existed immediately before the war. The sale price of sulphate of ammonia was very high, much higher than the price immediately before the war, or than the price will be in the future (see article in your journal of Dec. 15, page 827). The cost of manufacturing the sulphate of ammonia was very low, lower than it is to-day or than it will be in the future, with the exception possibly of a few localities. The shale to be retorted was low in yield of oil, but relatively high in yield of nitrogen. Money and machinery were low in cost.

What are the local conditions in the U. S. and in Canada? The sale price of oil is high, while the sale price of sulphate of ammonia will be very low, yet the cost of manufacturing the latter will generally be very high. The shale to be retorted is comparatively high in oil, but in the States generally low in nitrogen, while in Canada the nitrogen contents are sometimes very high, although deposits are found where the nitrogen contents are low. Money is dearer than in Scotland, and machinery, when erected, will cost much more. In fact nearly every condition to be faced on this continent is different from the conditions that existed in Scotland and which were responsible for the construction of the Scotch dual purpose retort.

Broadly, it may be claimed that while local conditions in Scotland at that time made the recovery of the nitrogen desirable, the local conditions existing in the States and Canada will make the recovery of the nitrogen generally unremunerative. This being the case, how can you or any one occupying a neutral position recommend or advocate the construction of the Scotch dual purpose retort, costly to construct and complicated to operate, a retort that costs more than double the price of the single purpose retort, while the accessories cost treble, upon all of which extra expenditures of capital there is likely to be no financial return?

The Scotch dual purpose retort is by no means a simple retort to operate, and if not carefully operated is liable to become damaged, entailing considerable loss of time and heavy expenditures for repairs. The requirements of the nitrogen-recovery half of the retort fight against the requirements of the oil-recovery half. The operator is ever "between the devil and the deep sea." If the heat is allowed to become lowered in the nitrogen-recovery half, the recovery of nitrogen is reduced; if the heat is kept up to the required temperature for good nitrogen recovery, the oil returns are reduced, and an excess of gas is produced. Owing to the constant variations in quality observed in all shale beds, or for other reasons, it is impossible so to construct the dual purpose retort that the requirements of the parts will never disagree.

Years ago was not the world told, "No man can serve two masters"? In the Scotch dual purpose retort this is what the operators have been trying to accomplish. That the efforts proved remunerative in Scotland, under the peculiar and special conditions then and there existing, is no justification for your advocacy of the adoption of this kind of retort, under conditions entirely different. Had you studied the history of the Scotch dual purpose retort, you would have learned that that retort has not been uniformly successful in its operation. You would have learned that when used for retorting shales of a quality different from that found in Scotland it proved a most disastrous failure. Did you never hear of the enormous amount of money lost in Australia through the failure of these dual purpose retorts? More money was lost than would have paid for all the experimental and "freak" retorts produced in the States and "then some," the construction of which is so deplored by Mr. Day.

I have a world of respect for Mr. David T. Day as a chemist, and also for the good work done by him on the oil shales of the United States, but this is not so much a problem for a chemist as for a business man with experience in operating chemical processes, and as such I have no hesitation in stating that the dual purpose retort, whether Scotch or American constructed, is not the retort required to-day to retort the majority of the shale found on this continent.

One of the experimental retorts mentioned by you is

the Wallace. Methinks I have read words of great commendation of this retort, made over the signature of David T. Day. Although I object to the intermittent method used of supplying the shale and of unloading the spent shale, especially when the shales being retorted are lean, I recognize that, if it be demonstrated by commercial operation that the oil contents of shale can be removed with only one hour of exposure to heat, this retort will cause a revolution in the designing and construction of retorts, a revolution that will give a black eye to all dual purpose retorts, be they Scotch or otherwise.

The retorting of shale will have to be considered on its own individual merits, that is, the retort and the working of the retort will have to be adapted to the quality of the shale to be retorted, and always with due regard to local climatic, industrial, financial and commercial conditions, the one aim being to secure for the men providing the money required for construction and operation the largest possible return upon their investment.

LOUIS SIMPSON.

Ottawa, Canada.

Instituto Cientifico Industrial del Salitre de Chile

To the Editor of Chemical & Metallurgical Engineering

Sir:—I am enclosing a copy of a circular letter which was distributed throughout Chile and resulted in the formation of the "Instituto Cientifico Industrial del Salitre de Chile." The idea has awakened very general interest in nitrate and allied circles which augurs well for the success of the project.

Knowing the general interest which is taken in Chilean nitrate in the United States, I think it might be useful to make public the knowledge of the awakening of the Chilean nitrate industry.

We shall be pleased to receive subscribers from the United States and hope that the steps taken here may find support among the scientific and technical societies of the United States in the many directions in which one society can assist another, and we trust that the interest which nitrate has aroused during the past years will lead to much research work in the U. S. A. which may help in one way and another to clear up many of the difficulties which beset the workers and the industry here.

BELISARIO DIAZ OSSA.

Santiago de Chile.

TRANSLATION OF SPANISH CIRCULAR LETTER

SANTIAGO, Oct. 12, 1918.

DEAR SIR:—The undersigned have the honor of inviting you to a meeting, which will take place on the 18th inst. at 2.30 in the rooms of the Sociedad de Fomento Fabril, Moneda 759, and which has for its object the formation of a scientific and industrial society in connection with the nitrate industry. You will deeply appreciate the advantages which such a society will confer not only on the country itself in its educational sense but also on the nitrate industry and those who are engaged in the study or direction of its different phases.

It is characteristic of the present period that there is a marked tendency to co-ordinate not only science and industry but also the workers who are occupied in the various branches of such scienece and industry, and there is little doubt that all those actually engaged in the various branches of the nitrate industry, in the technical studies relating to the process in use or in projection, or the actual manufacture and commerce of nitrate of soda will find, in a society of this kind, a new field for their activities, a place in which they can expound their ideas and discuss with their co-workers the different phases of the problems which are presented continually. Societies of this class, which aim at the reunion of men of science and of commerce, exist in almost all countries and for almost all industries, many of these latter being of less importance and of less vital interest than is the nitrate industry for this country.

The war has demonstrated the absolute indispensability of this class of society for the harmonious development of all industries. Governments have endeavored, even by compulsion, to form them where previously they did not exist, and have stimulated existing ones by the esteem with which they have regarded their activities. As an example, it will suffice to cite the case of France, where, in order to give the greatest development to French industries, both chemical and allied, the "Societé de Chimie Industrielle" was founded in 1917, whose valuable work is now beginning to make itself evident.

There exists in this country sufficient of the necessary elements for the formation of a similar technico-industrial society, but at the present time these factors are disunited and dispersed, and even without knowledge of one another, and our idea is to unite these for the general good and for the good of the industry and themselves.

One of the most important activities of the society will be the publication of a "Review" in which will appear not only original contributions on work done or being done of scientific as well as of commercial and technical interest, but criticisms of such contributions, discussions and abstracts of all work done in other countries in analogous industries, patents as well as original research.

This will bring about the necessary co-operation of the technical, scientific and commercial efforts which are being made individually to-day, and will form, at the same time, a bond of union between the nitrate industry and the chemical industry of other countries greatly to be desired.

We trust that this idea will meet with your views, and that you will lend us your assistance in bringing this society into useful existence.

J. BERKWOOD HOBSBAWN,
BELISARIO DIAZ OSSA,
J. L. GRIGIONI.

Classifying the Perkin Medalists

To the Editor of Chemical & Metallurgical Engineering

SIR:—If industrial chemistry is divided into the branches shown in the following table, the Perkin Medalists are distributed, according to their work, thus:

		Engineering Chemistry	Industrial Inorganic Chemistry	Metallurgical Chemistry	Industrial Organic Chemistry	Industrial Electro-Chemistry	Industrial Chemical Processes
1	1906	.....	.....	.....	*Perkin*	.....	.....
2	1908	.....	Herreshoff	.....	.....	Herreshoff	*Herreshoff*
3	1909	.....	.....	.....	*Behr*	.....	.....
4	1910	.....	Acheson	.....	.....	*Acheson*	.....
5	1911	.....	.....	Hall	.....	*Hall*	.....
6	1912	.....	*Frasch*	.....	Frasch	.....	.....
7	1913	.....	.....	*Gayley*	.....	.....	.....
8	1914	.....	.....	.....	*Hyatt*	.....	.....
9	1915	.....	.....	.....	.....	*Weston*	.....
10	1916	.....	.....	.....	*Baekeland*	Baekeland	.....
11	1917	.....	.....	.....	*Twitchell*	.....	.....
12	1918	.....	.....	*Rossi*	.....	.....	.....
13	1919	.....	.....	.....	.....	.....	*Cottrell*
Total...		None	1	2	5	3	2
Worthy of mention, in addition...		None	2	1	1	2	None

There is such inspiration in the record of these men that I should like to see a memorial volume published in which their lives and works would be available. The presentation proceedings might possibly form a starting point. To me this award is an outstanding thing in industrial chemistry today in the United States.

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Western Chemical and Metallurgical Field

Electric Pig Iron For British Columbia

STANSFIELD'S recently issued report on electric smelting of the iron ores of British Columbia is not a particularly encouraging document for the proponents of a west-coast iron industry. The author has been assured by competent engineers that accessible power could be developed for $10 per horsepower-year, but the present available surplus from the British Columbia Electric Railway Co. would cost $27.80! It may also be safely assumed that there is available an adequate supply of magnetite (50 to 55 per cent iron). Still, considering the fact that the entire consumption of pig iron in British Columbia is but 10 tons daily, while a plant large enough to give a moderate overhead would produce five times as much, the chance of marketing the output seems rather dubious. In the light of the recent experience of our own Western electro-alloy plants, the suggestion that ferromanganese, ferrochromium and ferrosilicon be produced when the demand for pig was slack does not strike a particularly responsive chord when considered as a means to increase the operating profit of the concern. Low-silicon pig for steel conversion could be made at any time, but its local utilization would require a highly specialized plant whose economical operation on such low tonnages is more than doubtful.

Electric shaft furnaces have been producing high-grade white iron in Sweden for many years, and this type is recommended for a permanent plant. For a cheaper, temporary installation the Electro-Metals pit furnace would probably suffice, Dr. Stansfield noting that the normal product could be made suitable for gray-iron castings by the addition of ferrosilicon. Magnetite low in copper, phosphorus and titanium is thought to be procurable, by water transport, at about $4 per ton. Magnetic concentration is mentioned as a possible method of increasing the tenor of the ore charge. Charcoal would be the reducing agent, obtained from the large quantities of mill-waste now available in the lumbering industry. By-products from Douglas fir are not sufficiently valuable to affect the production costs materially, but Dr. Stansfield thinks that by charring in large kilns, the labor charges may be reduced to a point where the coal can be laid down at about $6 per ton.

Summarizing, the cost per long ton of foundry iron is estimated as follows:

Iron ore, 2 net tons at $4	$ 8.00
Electric power, 0.45 hp.-yr. at $15	6.75
Charcoal, 0.4 net tons at $8	3.20
Electrodes, 15 lb. at 8c.	1.20
Repairs and maintenance	1.00
Labor	4.50
Management	2.00
Interest, 6 per cent on total capital, and depreciation, 10 per cent on cost of plant	2.60
Royalty to Electro-Metals Co.	0.50
Total	$29.75

At this price, electric furnace pig would be on a par with imported blast furnace pig, under the present tariff of about $5. A local iron and steel plant, using coke blast furnaces, is not to be expected for a number of years; eventually blast furnace pig will command the market, but electric furnace iron should always rule the market for high-grade material.

The final recommendations are:

(a) To develop one or more of the best iron ore deposits and to make complete tests of the ore.

(b) To reserve a suitable water power for future development.

(c) To establish a plant for the economic production of charcoal from mill waste.

(d) To investigate the new process of Trood and Darrah for the production of electric pig iron, and if this is found satisfactory to begin immediately to produce the pig iron, purchasing power for this purpose until the water power can be developed.

Collapse of Kelp Potash

A highly unsatisfactory situation has been suddenly brought about with respect to the Coast potash and kelp industry—particularly disappointing to those who were in hopes that the kelp industry could be perpetuated. Briefly, the armistice and its attendant events have caused the plants to close. There are still some exceptions, but apparently their operators have in mind the cessation of operations at an early date.

It has been evident for quite a while that the closing of some of the plants could hardly be postponed to the end of the war, since these were being operated by people not possessed of the requisite skill and experience to run a chemical factory. Some of the minor plants were started ill-advisedly, and even as "wildcats," and were later taken over by other people in order to save their investment. Under these circumstances it was scarcely to be expected that any great success as pioneers would follow their efforts. Their poor extraction of potash by crude and simple methods contrasted strongly against the very profitable manner in which this was done by others working under the same conditions, and they could scarcely be expected to produce the more refined products which kelp will yield and which must be depended upon to pay the way despite cheap potash.

The Hercules Powder Co.'s plant at San Diego,[1] the largest kelp concern in existence, ceased operations because its products were principally those which enter the war industries (all of which tumbled in price the moment the war terminated). Its potash, being a very high-grade chloride, was utilized in the preparation of potassium nitrate. Its acetone, of course, went into the manufacture of munitions. Prominent among other products were various aëroplane dopes. Other things it was manufacturing, such as acetic anhydride, the rare esters, and alginate bodies, while of importance and very great promise, were not sufficient to take the place of the decreased value of the other products. Had its operations continued for another year or two, this plant would have taken its place among the most important chemical factories in the country. But, of course, throughout the war period the greatest efforts were devoted to the production of war materials, the other researches being somewhat incidental and not carried far enough to permit the continuation of operations. The company had re-

[1] See METALLURGICAL & CHEMICAL ENGINEERING, Vol. 18, No. 11, p. 576.

cently inaugurated an advertising campaign to bring these various interesting and rare substances to the attention of the chemical public, but this had not gone far enough to yield results. Its scientific staff had done work which constitutes one of the most interesting chapters in American chemistry. Fortunately the data secured there are not going to be lost, but it is a misfortune that the promising young industry represented by the fermentation of kelp could not be added to our permanent national assets.

The Diamond Match Co. has caused its plant to be dismantled. Very little is known concerning the success of its operations, but evidently the management is confident it will now be able to obtain its requirements cheaper than it can produce them from kelp. This plant produced no by-products and did not get a quantitative extraction of potash from its rather expensive process.

It seems well accepted that it is not possible to produce potash from kelp commercially in normal times by any of the means so far tried, where no by-products are recovered. This statement possibly covers the reasons for the closing of the Lorned Manufacturing Co.'s plant at Summerland (whose operations were described in CHEMICAL & METALLURGICAL ENGINEERING for Sept. 26, 1918; Vol. 19, p. 450) and the Pacific Products Co. at Long Beach. These concerns have taken the position that the best time to close their plants is promptly upon the termination of a period of profitable operation and not to postpone it to a time when, through a sudden fall in the market price of potash or some accident to their plant, losses might be incurred which could not be recouped. This is entirely logical.

At Long Beach the Sea Products Co. still continues. This plant invested but a small original capital, and its profits by conservative and fortunate management have been great. It has paid for itself several times, and so its directors feel that they are justified in prolonging its operations. The Swift Fertilizer Co. at San Diego is still operating, and possibly will continue. Its plant has been a satisfactory potash producer, and it will possibly produce valuable by-products somewhat later.

Unfortunately, the experiments made at the Department of Agriculture's plant at Summerland have not been carried to that point where the Government's agents can say to the managers of the producing plants just what their costs and returns would be for the various by-products established as procurable and which offer definite promise of profitable extraction. Furthermore, to produce these substances would require a quantity of additional apparatus which would possibly double their present investment, and which of course they could hardly be expected to incur without a definite view of its ultimate recapture.

Gold Miners Present Program

Black Hills Mining Men's Association met at Deadwood, South Dakota, on Jan. 10, for a thorough discussion of the situation which confronts the gold producer in that district as well as in other parts of the world. Recognizing the real need of more gold, the continuing high cost of labor, machinery and supplies, the decreasing grade of ore in operating properties and the decadence of prospecting, the association passed resolutions prepared by H. W. SEAMAN, asking their State Legislature to memorialize Congress for relief along the following lines:

1. Remove restrictions upon the sale of bullion in domestic and foreign markets.
2. Allow liberal figures for plant depreciation and mine exhaustion.
3. Remove or refund special war taxes.
4. Exercise pressure toward more reasonable prices for machinery and supplies.
5. Extend aid to all endeavors to produce *new* gold.

Chloridizing Volatilization of Complex Ores

Metallic volatilization in complex ores in 100-lb. lots has been under experimentation for the past six months at the co-operative laboratory maintained by the Bureau of Mines and the University of Utah. A small-sized but rugged rotary kiln, 20 ft. long and 13 in. clear inside diameter is heated by oil burners. Ore is broken to 16 mesh, mixed with a proper amount of calcium or sodium chlorides, and fed to the upper or cool end of the kiln. Rotation of the furnace gradually works the mixture through, emerging approximately at 750 deg. C., this temperature varying somewhat for different ores. Seemingly oxides, carbonates and silicates of silver, gold, lead and copper are driven off as chlorides by this treatment, volatilization on silver ordinarily amounts to 75 per cent or better, while less than 10 per cent of the gold, lead and copper with all of the zinc remains in the residue. In furnacing, the coarser kernels of ore retain their original shape, while the fines roll up into small friable balls.

Fumes from the kiln are sucked through appropriate dust chambers by a fan, and then delivered to a Cottrell precipitator. Practically all of the coarser dust and considerable fume are collected in the chambers, while much of the finer fume is caught by electricity—an additional Cottrell treater is contemplated in order to better the final recovery. A certain degree of humidification may be necessary before complete clearance is effected, however. Dust and fume are melted with a limestone flux; by this means the metallic chlorides are reduced to metal, with the formation of a calcium-chloride slag, which, of course, may be pulverized and reused as a volatilizing reagent.

THOMAS VARLEY is the metallurgist now in charge of the station, although this experimentation has been in course of development for a long time under the personal direction of R. H. BRADFORD, professor of metallurgy at the university.

Passing of Goldfield Consolidated Mines Co.

After having produced in excess of $70,000,000 and paying dividends in excess of $28,000,000, Goldfield Consolidated Mines Co. has, within the last two years, extended its leasing policy until the small amount of remaining ground does not justify maintaining the staff and machinery necessary for its administration. A 5-yr. lease has therefore been given on the entire mining property, mill excepted, to an independent Goldfield Development Co. on a basis of royalty on ore produced, equaling 15 to 20 per cent of the proceeds from its sale, after deducting marketing charges.

New York Meeting of the American Institute of Mining Engineers

Annual Meeting Is Marked by Large Attendance and Excellent Program—Joint Sessions Held With Canadian Mining Institute—Special Attention Given to Industrial Relations—Change of Name and Election of Officers

THE first post-war meeting of the American Institute of Mining Engineers, held in New York City Feb. 17-20, showed in its attendance and general atmosphere the freedom and removal of restraint which the end of hostilities has brought to the engineering profession. There was a generous sprinkling of military uniforms at the various gatherings, worn by engineers who have not yet been mustered out of the service; but for the most part those members of the profession who had been giving so much of their time to war work had been relieved from public duties and were enjoying this opportunity for professional intercourse. More than 700 men registered during the meeting, giving the largest registration in the history of the Institute. The annual banquet was attended by more than 400, and all the technical sessions were well patronized by interested audiences.

Institute Changes Name and Elects Officers

At the annual business meeting it was announced that the proposed amendment to the constitution, changing the name of the Institute, had been carried, and that the name henceforth would be American Institute of Mining and Metallurgical Engineers. This alteration has been proposed for some time past in order to give recognition to the large membership of metallurgists in the organization. It is hoped also that the change will induce many more to join whose interests are primarily metallurgical rather than mining. This is particularly true of metallurgists engaged in the production of iron and steel.

Horace V. Winchell of Minneapolis was elected president for the ensuing year. Other officers elected were: Vice-presidents, Edwin Ludlow, A. R. Ledoux; directors, J. V. W. Reynders, George D. Barron, Charles F. Rand, Louis S. Cates, Stanley A. Easton.

In his annual report the secretary showed that the Institute membership increased by 666 during the year 1918, giving a total of 7158 on Dec. 31, 1918. The financial condition of the Institute is excellent, as shown by the audited treasurer's report of $8258 on hand.

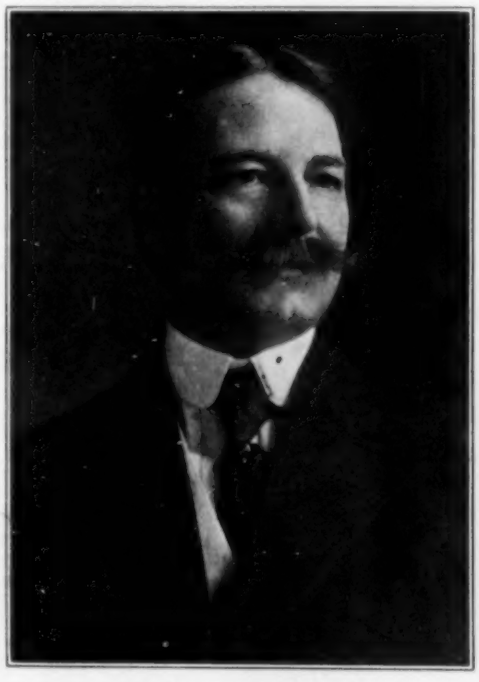
Participation by Canadian Mining Institute

Tuesday, Feb. 18, was designated Canadian Mining Institute day, and was marked by joint discussions on the subjects of mine taxation, industrial relations, democracy and education, and uniform mining law for North America. President Dowling, Secretary Lamb and a delegation of members of the C. M. I. were in attendance and contributed to the discussions. The greatest interest attached to the paper on "Industry, Democracy and Education" delivered by Mr. C. V. Corless, director and manager of the Mond Nickel Co. His address was brilliant, forceful, logical and filled with choice epigrams. Based on the highest idealism, it nevertheless carried the greatest conviction, due to the earnestness of the speaker and the evident practicality of his ideas. Mr. Corless began his address with an inquiry into the causes underlying the unrest which exists throughout the world, and showed that they were not new, but were such as humanity had rebelled against for ages past—autocratic rule, not only political but

industrial as well. The prime cause of the great war he found in a conscious effort to perpetuate autocracy in political affairs. Similarly the cause of unrest in industry is not primarily low wages, long hours, no vacations and few holidays, but its essence is the individual's lack of interest in the end product of his toil. Having no chance to display his intelligence or imagination, he rebels against an external authority which he does not share.

Mr. Corless declared that political democracy and industrial autocracy cannot exist side by side, and stated that the great need of the world is democratic freedom and self-government in industry. The latter will be accomplished only by lifting the industrial problem out of the mire of sordid and selfish commercialism, and considering it from the enlightened viewpoint of right and justice in human relations. Slavery has been abolished as a political institution, and autocratic rule in industry must follow it to the scrap heap.

The Whitley scheme of industrial representation which is being tried in England met with Mr. Corless' approval as a large and necessary step forward toward industrial peace. "It is necessary to saturate our minds with the idea that the democratization of industry is fundamentally necessary," he said. Our industrial organizations have been turning out two products, one material and the other human, and we have been neglecting the latter to the point where it leaves the factory in worse condition than it entered. As a fundamental prerequisite to social democracy, Mr. Corless stated that the people must be educated to think economically, ethically and socially. We are at the beginning of a great transition period in industry, coincident with the end of the autocracy of capital. A new form of society cannot be created by changes in a political constitution, but it must find its inception in a quickening of the minds of the people in matters of justice and right. The discussion of those topics which were the subject of joint consideration in New York will be continued at the meetings of the Canadian Mining Institute in Montreal, March 5-7, 1919.



HORACE V. WINCHELL

Memorial Services

The life and work of Dr. Rossiter Worthington Raymond, past president, honorary member and secretary emeritus, were the subject of a memorial service during the session. Dr. Henry F. Drinker, president of Lehigh University, and Mr. T. A. Rickard, editor of the *Mining & Scientific Press*, spoke on the personal and professional attributes and attainments of Dr. Raymond. Both had enjoyed a long acquaintance and friendship with him and were able to speak appropriately. The Institute plans to issue a memorial volume containing tributes to the life and work of Dr. Raymond, as well as a history of the Institute which he had begun but not finished.

Services in memory of Institute members who lost their lives in the military service of their country were conducted by President Jennings. The Institute had about 845 members in the service, of whom, so far as is known, about 25 have died.

Social Features of the Meeting

The committee on arrangements promoted sociability among the visitors by various means. The noon luncheons served at headquarters were most effective in bringing together the members for a social hour. The smoker on Monday evening, with Mr. E. P. Mathewson as ringmaster, was a success from every point of view, contributing not only entertainment but also instruction. A new development in moving pictures was shown, by which it is possible to illustrate the internal action of mechanical devices, such as gas engines, machine drills, etc. Pictures on this order were used extensively during the war for the instruction of recruits, and should be quite as effective for industrial purposes. There was a large attendance of ladies at the meeting, and suitable entertainment was provided for them. Visits to Senator Clark's galleries, a theater party and trips to various points of interest in New York were arranged. The ladies also attended the noon luncheons at headquarters, and the lecture by Lieut. Pat O'Brien, who told of his capture and escape from Germany. About 350 members and guests of the Institute visited the shipyards of the Federal Shipbuilding Co., Kearny, N. J., to inspect the methods of fabricating steel ships. This company was organized by the U. S. Steel Corporation to assist the Government in its war program, but is now turning out ships for merchant trade. The yard has 12 ways and a fitting-out basin accommodating eight ships at once. The ships are 410 ft. long, 55 ft. beam and 27 ft. draft, with a cargo carrying capacity of 9600 tons. The visitors were shown through the shops and one of the ships, after which the company served luncheon at one of the dining rooms on the grounds. During the early part of 1918 experiments were under way at this yard for electric welding, with a view to building ships without rivets, but the sudden termination of hostilities brought the plans to an end.

Sessions on Industrial Organization

Two sessions were devoted to the problems of health, sanitation, housing, education, methods of employment, mental tests, Americanization, etc. Methods of employment of labor and the new change in industrial relations were discussed by Mr. H. M. Wilson, who said that the experience and knowledge of engineers impose on them the imperative duty of participating in the

solution of labor and capital problems. In the latter he saw four factors—labor, capital, the community and the managers. Most disagreements, he believed, resulted from the fact that both the employer and the employed were too engrossed in their own personal problems to sense each other's side of the question. In the Rockefeller plan of industrial representation and conference between managers and laborers, Mr. Wilson thought that a fair solution of the problem had been found. He also approved the Whitley scheme of the British.

The Use of Cripples in Industry was outlined by MR. JAMES P. MUNROE of the Federal Board for Vocational Training, which is assisting discharged soldiers who are handicapped by injury or disease. Through compensation by the War Risk Insurance Bureau and training by the Federal Board for Vocational Training, the discharged soldier is prepared for industry and is not allowed to remain a "cripple" in the old meaning of that term. This war work has shown the possibilities of retraining those who are disabled in industrial pursuits, and brings to the Federal Board a larger problem than it has in connection with disabled soldiers. Twenty thousand of the latter are to be retrained for industrial pursuits, but a larger number than this must be handled as a result of accident and carelessness in industry. In addition to this work the Federal Board has taken over the training of employment managers, begun by the War Industries Board, and plans also to give short courses in safety, etc., in schools where vocational training is being given.

Mental Factors in Industrial Organization and the part they play in labor problems were presented by MR. THOMAS T. READ. "The first requisites of success in industrial organization . . . are unity of purpose and co-ordinated activity." Failure to secure these requisites is caused in part by lack of opportunity for self-expression by the laborer in our modern industrial systems; in part by mental abnormalities in the individual which result in breaking down unity and co-ordination.

Mental Tests in Industry, the subject of one of the most interesting papers on the program, was dealt with by MR. ROBERT M. YERKES. The author gave a review of the mental tests adopted by the Army for grading enlisted men and officers as to intelligence, and showed that the gradings thus obtained were supported by classifications made later from everyday experience. He thought that these tests or similar ones should be of value in selecting men for industrial pursuits instead of leaving the choice to cut-and-try methods. The tests were prepared by a committee of the American Psychological Association and the National Research Council, and are applicable to men in the mass, say up to 500 at one time. The results are valuable for determining a man's probable limitations in various occupations, and for determining average intelligence standards for different kinds of work. In all the tests engineers stood at the head of the list. These tests have relation to intelligence only, and do not refer to temperament, moral qualities or effect of special training. So far as the Army was concerned, the tests showed that intelligence was the most important single factor in military success; and it is believed that good results can be obtained by their application in industry.

Fine Crushing in Ball-Mills was presented at some length and in mathematical form by MR. E. W. DAVIS. The author conducted his tests with Mesabi magnetite, sp.gr. 3.4 and hardness 7. The following deductions are drawn from more than 150 operating tests:

1. In every case an increase in the tonnage fed to the mill resulted in an increase in the efficiency.
2. In every test the limiting factor of the test was not the ball-mill, but some auxiliary apparatus, usually the classifier.
3. All tests point to the fact that the ball-mill is a machine of very large capacity, especially if it is provided with proper auxiliary apparatus.
4. Classifying and pulp-handling machines that will handle a circulating load of at least 500 per cent of the original feed should be provided.
5. Closed-circuit crushing is more desirable than open-circuit.
6. The real advantage in closed-circuit crushing lies in the fact that the maximum size of particle is nearer the average size of particle discharged from the circuit.
7. Two-stage crushing is more efficient than single-stage.
8. The real advantage in two-stage crushing lies in the fact that the ball charges can be adjusted more nearly to the required conditions.
9. Two-stage open-circuit crushing does not present this advantage, as the maximum-sized particle in both stages is more nearly the same.
10. The proper adjustment between size of balls and speed of mill can be secured by an examination of the classifier sands.
11. If the balls are large or the speed is high, the screen analysis of the classifier sands will be crowded at the finer sizes.
12. If the balls are small or the speed is low, the screen analysis of the classifier sands will be crowded at the coarser sizes.
13. From the data at hand, the indications are that the best efficiency is obtained when the screen analysis of the classifier sands shows a minimum of crowding at any size.
14. Balls no larger than necessary should be used, as this makes it possible to charge the mill with the greatest number of balls.
15. Balls smaller than can crush the larger particles of ore should not be kept in the mills, as they take up space, absorb power and do inefficient crushing.

Following are some of the conclusions as to operation of ball-mills:

1. By use of formulas the proper theoretical speed for the operation of the mill may be computed.
2. This speed is correct only when there is no slipping between the charge and the lining of the mill, and when the pulp is not so thick as to produce strong adhesion between the particles.
3. In actual practice it may be found that more effective crushing can be done at some other speed, but it would appear that the variations above or below this theoretical speed should be small.
7. The amount of crushing done depends upon the number of blows struck and the work done at each blow.
8. The number of blows struck can be increased by increasing the number and decreasing size of balls.
9. The work done at each blow can be increased by increasing the weight of the ball and by increasing the diameter of the mill.
10. From this it follows that mills of larger diameter should be charged with smaller balls and mills of smaller diameter with larger balls, when working on the same feed.
11. The proper operating speed of a ball-mill varies inversely as the square root of the diameter.
12. The proper operating speed of a ball-mill increases as the size of the ball load increases.
13. Due to interference between the balls, the volume of the charge should not be over 60 per cent of the volume of the mill.
14. Unless great care is exercised to prevent slippage, the volume of the ball charge should not be less than 20 per cent of the volume of the mill.
15. It would then seem that a ball charge that occupies between 30 and 50 per cent of the volume of the mill will give the most satisfactory results.
16. In an 8-ft. (2.4-m.) mill running at 22 r.p.m., with a 28,000-lb. (12,700-kg.) charge of 2-in. (50.8-mm.) balls, there will be an average of about 1,000,000 blows per minute; each of these blows will be equivalent to dropping a 2-in. ball 5 ft. (1.5-m.).

Conclusions on ball wear are summarized as follows:

1. In any mill, the rate at which the weight of any ball decreases is directly proportional to its weight.
2. In any mill, the rate at which the diameter of a ball decreases is directly proportional to its diameter.
3. In any mill, the rate at which the surface of any ball decreases is proportional to its surface.
4. Since the rate at which a ball loses weight varies as the work done upon it in the mill, it follows that the work done in wearing (or crushing) the ball varies as the weight of the ball. This is seen to be Kick's law.
5. It then appears that Kick's law holds true for the ball wear in a rotating mill.
6. The natural tendency is for the small balls to accumulate in the mill charge.
7. Since these small balls do very little crushing, and exclude ore and larger balls from the mill, if allowed to accumulate too long, a marked decrease in crushing efficiency will result.
8. Since the large ball is just as likely to strike the small pieces of ore and the small ball is just as likely to strike the large pieces of ore as the reverse, it would seem that all of the balls should be of a size to crush any of the particles of ore.
9. This means that the balls should be as nearly as possible of a uniform size.
10. Since spheres of uniform size provide the greatest amount of interstitial space, a mill charge composed of balls of uniform size will allow freer migration of the ore particles than a charge containing balls of different sizes.

Methods of Concentrating Manganese Ore were considered very broadly in a paper by MR. EDMUND NEWTON. The author gave no specific examples of concentration, but offered the following outline of methods that might be used, with due regard to the nature of the ore, size of deposit, location and other economic factors:

Simple Methods of Concentration:
- (*a*) Selective mining.
- (*b*) Hand picking.
- (*c*) Jigging.
- (*d*) Screening.
- (*e*) Log washing.
- (*f*) Water classification.
- (*g*) Roughing table treatment.
- (*h*) Slime table or vanner treatment.
- (*i*) Pneumatic separation.
- (*j*) Combination of two or more of the above.

Complex Methods:
- (*a*) Magnetic separation:
  1. Without preliminary thermal treatment.
  2. With preliminary thermal treatment.
- (*b*) Electrostatic separation.
- (*c*) Hydrometallurgical processes:
  1. Leaching with various acids. Precipitation by chemical substances.
  2. Leaching with various acids. Precipitation by electrolysis.
  3. Leaching with various acids. Evaporation of solution and heat treatment in rotary kiln.
- (*d*) Preliminary thermal processes:
  1. Drying, to remove hygroscopic moisture.
  2. Calcining, to remove carbon dioxide or combined water.
  3. Agglomerating fine concentrates to make them desirable for blast-furnace use.
  4. Volatilizing manganese at high temperatures in the presence of certain constituents which form readily volatile compounds.
  5. Direct reduction of oxides by carbon, under temperature control.
- (*e*) Miscellaneous processes:
  1. Flotation.
  2. Use of heavy solutions.

MORNING SESSION OF INSTITUTE OF METALS

Two sessions of the Institute of Metals Division occurred on the first day, largely attended by an euthusiastic group. Illustrating the wide range of interest, the feature of the morning was a discussion of the amorphous theory, and of the afternoon an appreciation of new methods in casting and melting manganese bronze. DR. ZAY JEFFRIES' paper entitled "Effect of Temperature, Deformation and Grain Size on the Mechanical Properties of Metals" is but one of a series of recent and important contributions to the knowledge of crystalline and amorphous phases of metal, and the mechanism of failure. The author cites experiments performed by himself and others showing diverse relations between strength, elongation and hardness as influenced by the rate of loading, temperature and past history, and then endeavors to explain many puzzling anomalies by a simple relation between cohesion and temperature of the metallic constituents. The subject is far too intricate for a short abstract, and is reserved for a later presentation at some length, especially since the amorphous theory as expounded by Jeffries is not universally accepted—as eminent an authority as Prof. Mathewson of Yale expressing his vigorous dissent from the idea of a truly amorphous phase, leaning rather toward a conception that a sub-crystalline superamorphous layer somewhat continuous with its surrounding metal is the cement which holds the crystalline aggregate together. Of interest to iron and steel metallurgists is the evidence drawn from Jeffries' curves between respectively, tensile strength, elongation or ductility and temperature. These show discontinuities at ranges between 30 and 300 deg. C., not entirely concordant, it is true, yet they present peculiarities easily explainable by the assumption of a low-temperature allotrope. This evidence may be sufficient to convince many metallographists who would like to postulate this phase.

VOLATILIZATION OF CUPROUS CHLORIDE ON MELTING COPPER CONTAINING CHLORINE

MESSRS. S. SKOWRONSKI and K. W. MCCOMAS, of the Raritan Copper Works, presented their results on the "Volatilization of Cuprous Chloride on Melting Copper Containing Chlorine." This is of much present importance, since any copper-leaching process giving chlorides either from the ore or solvent will electrolytically deposit cuprous chloride on the cathodes, which, if readily volatile, would represent large metal losses. It has long been known that in melting copper known to contain chlorine, the fumes evolved have been sufficient to interfere with the charging or to drive the workmen from the building, and that flue dust from furnaces melting copper with but traces of chlorine will analyze up to 15 per cent cuprous chloride. Experimentally, a small amount of copper containing various percentages of chlorides was melted and the volatilized copper chloride determined. The results, figured to a ratio of volatile copper to volatile chlorine, varied from 1.66 to 1.76 when melting under carbon dioxide, air, or furnace gases, as compared to a theoretical figure of 1.79 for total volatilization, and therefore it is considered that under present refinery practice all cuprous chloride in cathodes will be volatilized and lost to the bath.

A short paper on "Automatic Copper Plating" by MR. J. W. RICHARDS called for some comment. Especially MR. A. SILVERMAN reviewed the method of copper-coating steel by casting copper, brass or cupro-nickel around a red hot steel core, then rolling or drawing the composite bar. He exhibited samples of the finished

material, which has been adapted to a wide variety of uses.

Other contributions which were read by title were an important description of the results obtained in the "First Year of Leaching by the New Cornelia Copper Co.," by MESSRS. H. A. TOBELMANN and J. A. POTTER; "Die Castings and Their Application to the War Program," by MR. CHARLES PACK; "Two Instances of Mobility of Gold in Solid State," by MR. EDWARD KELLER; and "Notes on Electric-Furnace Problems," by MR. J. L. MCK. YARDLEY.

AFTERNOON SESSION OF INSTITUTE OF METALS

The feature paper of the Institute of Metals Division's afternoon program was MR. P. E. MCKINNEY'S paper on "Manganese Bronze." Mr. McKinney is metallurgist at the naval gun factory in Washington, and describes the methods he has used for over three years in the manufacture of highest grade manganese bronze castings by melting scrap materials in an open-hearth furnace. For instance, 250 lb. of a manganese hardener (scrap copper alloyed with ferromanganese) is placed in the bottom of the furnace; next is a ton of dross and skimmings from the cartridge-case plant and 400 lb. of zinc dross from the galvanizing plant. Seventy-five pounds of charcoal for reducing agent is next spread over the charge, and the balance of the heat added—principally yellow-brass turnings, zinc scrap, foundry scrap and skimmings. Common salt (80 lb.) is used to flux the dirt and collect oxides of iron and manganese. The reactions which form a bath of quiet metal from this mixture are similar to those in old-fashioned calamine-brass manufacture, while the small amounts of iron, tin and lead ordinarily added to virgin metal already exist in the waste materials used. Over a million pounds of castings per year have been made in this manner, ranging from small work to pieces of nearly ten tons, and while the lead content ordinarily is much above naval specifications, test bar results have been quite high, and the finished castings have withstood severe war service—which, doubtless, is the end and aim of a specification.

MR. J. L. JONES emphasized that the method could hardly be used with success in any but a large foundry, which has available a large supply of scrap of known origin and uniform analysis. Close chemical control is necessary, of course, and the speaker emphasized particularly the necessity of Mr. McKinney's practice of deoxidizing with aluminium and casting the original melt (figured to make a correct alloy) into ingots, which could then be analyzed and remelted with necessary corrective additions.

MANGANESE BRONZE MANUFACTURE

MR. G. H. CLAMER outlined interestingly the history of manganese bronze manufacture since "Parson's metal" was first made by the Cramps some twenty-five years ago. In particular he pointed out that this paper controverted the idea that a reverberatory is a bad place to make brasses, on the basis that it was hard to regulate the atmosphere and large oxidation losses in zinc and aluminium would therefore result. Especially the latter produces an infusible oxide which is hard to flux and is liable to segregate in the casting. The analyses quoted showed much higher lead than would be accepted from private manufacturers, and if the Government specification would be changed to correspond with the demonstrated facts, much waste and second grade metal could be utilized by all bronze-makers.

Many speakers contributed bits from their experiences. Especially was it emphasized that the results from test bars, whether cut from coupons, sink-heads, or hollow-milled from the body of the piece, depended to a preponderating extent upon molding practice; that is, of two of the same patttern, cast from the same heat at the same temperature, one, if properly gated and with correct risers and heads, would test perfectly, while the other, badly gated and with inadequate allowance for shrinkage, would test very low.

MESSRS. W. H. BASSETT and C. H. DAVIS, recognizing the impossibility of testing thin sheets in a Brinell machine, have worked out "A Comparison of Grain-size Measurements and Brinell Hardness of Cartridge Brass." Fig. 1 gives their results. At low annealing temperatures the grain size is influenced by the grain size of the previous anneal; but from 0.060 mm. upward the relation is unaffected by the history of the

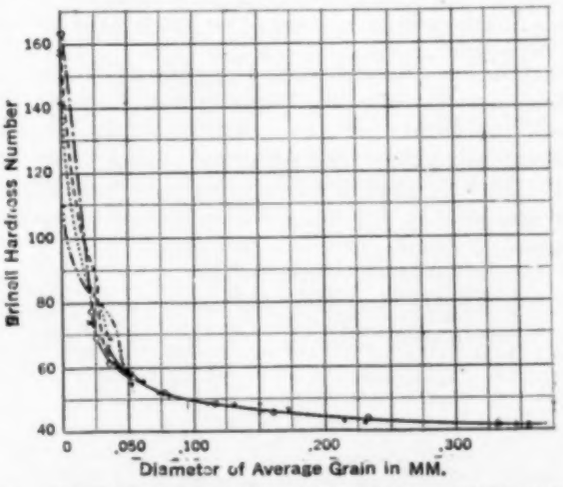


FIG. 1. BRINELL HARDNESS INDICATES GRAIN SIZE FOR ANY GIVEN BRASS IN THE ALPHA PHASE

piece. The grain size and the Brinell hardness change progressively with the percentage of copper in brasses, but their relation is a constant for each brass mixture in the alpha phase. Major White in commenting upon the fact that grain size measurements, as specified for sheets less than 0.1 in. thick, are slow and subject to the operator's personal equation, said the Bureau of Mines had worked up a "Baby Brinell" which was capable of testing thin sheets satisfactorily, and would prove valuable to quick, easy and adequate inspection of thin brasses.

Many of the metallurgists present had heard of colloids, and some had a dim conception of what the term was designed to express, but few had ever considered that such matters had definite application to their science until it was pointed out in a brief but very suggestive paper by MR. JEROME ALEXANDER on "Metals and Alloys From a Colloid-chemical Viewpoint." Particularly he urged thought toward development of methods to make sufficiently thin sections to be used under the ultramicroscope, with a view of attacking moot problems in the constitution of certain metallic phases.

Unusual occurrences abounded at this New York meeting. Not the least was the appearance of a feminine author. MISS LILIAN ERSKINE, of the New Jersey Labor Bureau, with a paper on "Standards for Brass and Bronze Foundries and Metal-finishing Processes." The paper dealt largely with the adequate provision of light, heat and air for the workers' health and efficient production in such plants—conditions not altogether easy to maintain at all times and seasons and therefore almost universally neglected. An appreciation of the money value of such comforts is spreading, however, and those who rebuild old or construct new foundries would do well to examine Miss Erskine's paper, or better, study the exhaustive material available at the New Jersey Bureau.

MORNING AND AFTERNOON IRON AND STEEL SESSIONS

Perhaps the most interest of the second day's sessions on metallurgical subjects was exhibited over the question of "Flakes," a defect in high grade steels which has recently caused much trouble. This subject is treated at length elsewhere in this issue and therefore it will not be repeated here.

MR. H. E. DOERR presented a short paper entitled "Does Forging Increase Specific Density of Steel?" describing experiments on several sound steel ingots in forged and unforged condition. Forging is shown to increase the density but very slightly, and thus controverts the popular conception, which would be true only for very spongy steel. MR. J. S. UNGER presented work indicating the opposite state of affairs to be true. As DR. H. M. HOWE pointed out, however, the specific gravity of steel is the result of various factors. As the carbon content and its heat treatment vary, the specific gravity changes owing to the different heaviness of cementite and the allotropes of iron. Gas cavities existing in cast metals may be closed in forging, increasing its weight, but on the other hand, forging has an almost irresistible tendency to open up a central pipe.

STATIC, DYNAMIC AND NOTCH TOUGHNESS

In "Static, Dynamic and Notch Toughness," the author, PROF. S. L. HOYT, called attention to the oftendisregarded fact that toughness is not synonymous with ductility, and that in general ordinary physical tests do not give an indication of the shock-resistant qualities of a piece of metal, especially if it is key-seated or used in the "notched" condition found at many places in modern machines. He therefore pleads for the adoption of a notched-bar impact test to determine a real factor of fitness for materials to be used in such ways. Various members contributed to the discussion, drawing attention to the extreme care to be exercised in order to get concordant results from shock tests, and to the need of an investigation to establish relationships between shock and fatigue tests. DR. MATHEWS emphasized particularly that internal notches, such as non-metallic inclusions, flakes or blowholes, are really more important in their effect on shock testing and actual service than are the external notches appearing by design.

MR. R. S. ARCHER gave the results of his work on the "Development of Grain Boundaries in Heat-treated Alloy Steels." It was found impossible to develop grain size in heat-treated chrome-nickel steels by ordinary etching agents. If, however, the steel be etched about ten minutes in a fresh solution of picric acid in ethyl alcohol, and the carbonaceous smudge polished off on moist broadcloth, the internal structure and any defects present were developed quite well, together with boundary "ghosts" of former crystals broken up into the extraordinarily fine crystals of hardened metal.

WATER-COOLED EQUIPMENT FOR OPEN-HEARTH STEEL FURNACES

Details of doors, frames, buckstays, port- and wall-coolers, valves and dampers were presented by MR. WILLIAM C. COFFIN, in "Water-cooled Equipment for Open-hearth Steel Furnaces." The author pointed out that the use of water-cooled equipment was, first, to hold the furnace to its lines, either in order to smelt correctly, or to relieve the brickwork from undue strains; second, to maintain the metal parts in question, and third, to increase the operators' comfort. On the other hand, the practice should not be elaborated to the point where the furnace would be cooled—in other words, the fuel burned in the furnace should refine metal and not melt refractories or heat cooling water. Practically, the desired result would be had in doors, for instance, by a one-course lining which fuses on its inner surface and burns back to a certain point where the heat radiating slowly outward is just sufficient to keep the hot portion solid. Ports are more difficult to protect since splashes of oxide flux the silica brick at temperatures as low as 1200 deg. C. At any rate, as pointed out by MR. UNGER, water cooling may be pushed to an extreme where the cost of fuel, maintenance, cooling water and the circulation of same is more than the savings in refractories, delays and metallurgical performance. As to materials of construction, welded steel plates are almost ideal, being uniform, thin and therefore conductive, strong and permanent. Cast iron, on the other hand, must be made with thick walls which are less conductive, therefore they warp out of shape and crack. Copper is somewhat more satisfactory, but it is expensive and difficult to cast in large masses.

MESSRS. J. S. MCDOWELL and R. M. HOWE presented a paper on "Basic Refractories for the Open Hearth," in which they gave results of laboratory tests on materials prepared from American dolomites and magnesites, largely used, as is well known, as substitutes for the imported material. While small-scale testing can never duplicate furnace conditions, the authors' work indicates that most satisfactory refractories may be made from Western magnesites low in lime, while non-slaking fettling may be made by coating granules of impure dolomite with basic open-hearth slag at high temperatures.

TWO NOVEL PROCESSES DESCRIBED

Two novel processes of manufacture were described by MR. J. E. JOHNSON, JR., and DR. J. W. RICHARDS, in their respective papers on "Davidson Process of Casting Formed Tools," and "Shimer Case-hardening Process." The first recorded the successful attempt to cast sound tools of alloy steels practically to shape which can be annealed, finished by light machine cuts, hardened and ground. Samples of intricate tools made by this cheap method were exhibited which comparative tests show to be equal to tools cut from rolled bars after

the usual method. Evidently successful tool-making by casting requires a thoroughly well-killed melt (effected by the use of a secret composition), producing no blow holes from dissolved gases or from green molds, fluid metal for making sharp castings, and a final metal satisfactory in physical properties. DR. RICHARDS' paper noted a successful war-time substitute which equals the case-carburizing action of the usual fused cyanide bath. MR. SHIMER found that a melt of easily fusible salts of commercial purity such as sodium, calcium and barium chloride will absorb calcined lump calcium cyanamide, with a lively evolution of gas, which effervescence continues as long as the bath has carburizing qualities. The rationale of the operation is as yet unknown.

A METALLOGRAPHIC INVESTIGATION OF TRANSVERSE-FISSURE RAILS

MR. G. F. COMSTOCK in "A Metallographic Investigation of Transverse-fissure Rails, With Special Reference to High-phosphorus Streaks," attempted to harmonize somewhat the views of various rail-failure disputants, one group holding transverse fissures to be from fatigue, others insisting them to be from poor quality. The author carefully examined 24 fissured and 12 sound rails of known history, examining and classifying their sulphur prints, inclusions of alumina and of slag, and the amount of free cementite and ferrite exhibited, without finding any general relationship between such defects and the location or presence of transverse fissures. When etching polished steel sections taken normal to the fissure with Stead's cupric chloride reagent, the thin film of copper ordinarily deposited on normal metal was absent on segregated phosphorus streaks, in many cases the most pronounced of which passed through the fissure's nucleus, and fissured rails were pronouncedly more streaked than sound ones. DR. P. H. DUDLEY vigorously contended that transverse fissures were not fatigue failures, since normal wheel loads and track construction induce stresses far below the elastic limit, and result from abnormal metal only. Since but one break in 1585 is due to this cause, it is practically impossible to investigate the phenomenon in any way but by tracing the rail back to the mill. This done, it seems that 90 per cent are from direct-rolled rails. Reheating the blooms results in better rails either through allowing more time for the slow diffusion of phosphorus, as suggested by Comstock, or more probably by healing the fractured structure caused by the blooming mill, or by producing more uniform hot bed annealing and making necessary less gagging in the finishing department. As MR. G. M. DAVISON pointed out, a method should be devised to detect internal faults after the rail was in the track and before it caused a wreck. Electrical and magnetic tests had apparently not proved as satisfactory as anticipated. In any case, metallographists would have to demonstrate the undoubted existence of phosphorus in the streaks and to determine its rate of migration at reheating temperature before Mr. Comstock's proposal could be accepted, in view of the fact that phosphorus in modern open-hearth rails is but 0.03 per cent, while older bessemer rails, with four times as much, are practically free from transverse fissures.

The most notable feature of the session of the National Research Council was a clear analysis of the metallurgical practice necessary to produce sound, high grade alloy steels for munition purposes presented by DR. H. M. HOWE as an abstract of the unpublished "Report of Steel Ingot Committee."

His discussion applied only to the production of highest grades of steel containing perhaps 3.5 per cent of nickel, with or without chromium, from pure materials, and may be summarized by the phrase "refine hot and pour cool." The cold charge melts at a temperature of about 1440 deg. C. in approximately 6 hours after charging, whereafter the temperature is run up rapidly to the maximum which the furnace will stand—in the neighborhood of 1670 deg. C. This is to deoxidize the bath largely by its contained carbon, so that the products may escape from the melt and furnace as a gas. When the refining is completed the temperature is dropped very rapidly to stop the further oxidation of the carbon, so that the analyses returned to the furnaces some half-hour later may have some meaning. If these agree with the specification, ferromanganese is added to the bath essentially to add manganese to the steel—no more than 10 or 15 per cent of it should be oxidized at this stage, since the resulting slags are not entirely eliminated from the steel, causing inclusions and ghosts. About ten minutes afterward, when the temperature of the bath has dropped to the required point, the heat is tapped, cooling materially in the ladle, where it is held perhaps 20 minutes for it to reach its correct pouring temperature, which latter is of the greatest importance. Slow pouring is also essential: A rapid pour chills a solid skin of metal next the mold, the mold is later heated considerably by the interior hot metal, it expands, leaving the thin skin unsupported. This cracks from hydrostatic pressure and liquid iron flows from the inside. Slow pouring gives thicker walls at the bottom, capable of withstanding the interior pressure; it also reduces piping by supplying the pipe, growing from the bottom upward, with fresh metal. Pouring at too low a temperature must be avoided as well—a point somewhat below the liquidus is best where the metal is in the form of a thin emulsion, thin enough to form smooth and strong, thick walls against the mold but not mushy enough so that inclusions cannot be slagged off.

DISTINCTION MADE BETWEEN "LADLE STEEL" AND "FURNACE STEEL"

In the discussion of this and the two following papers a sharp distinction was made between "ladle steel" and "furnace steel"; one made with additions to open-hearth metal during tapping, while the latter denoted that all deoxidizers were charged in the furnace. DR. HOWE recognized the fact that tank-steel may readily be made economically by ladle addition, whereas cannon-steel certainly could not. Since metal is tapped below the liquidus, any solid ladle addition first chills a thick shell of solid steel about it, which later must be melted before diffusion can begin. MR. H. D. HIBBARD thought that for safety steel makers should adopt the rule to make only the best steel, but MR. F. N. SPELLER pointed out that this would hardly hold in all cases, since, for instance, certain welding steels cannot be produced by electric-furnace methods. In other words, impurities may at times be of value, and at other times

be of no harm—sash weights of melted tin cans are thoroughly good.

Two papers on manganese were read which would have been eagerly devoured six months ago, but to-day appear to be largely of historical interest. MR. P. H. ROYSTER'S study of the "Production of Ferromanganese in the Blast Furnace" presented a table of operating quantities gathered from eleven furnaces, wherefrom he draws information as to approved practice. Contrary to expectation, a high blast temperature does not appear to be as important as a basic slag in influencing the amount of manganese lost at the cinder notch. Leaving the alumina out of consideration, the author finds the ratio of bases to silica for good slags is usually 1.5, although it may reach the figure 2. Experience also bears out the common impression that it is easier to reduce losses by reducing the slag volume rather than the percentage of manganese in the slag—in other words, use only the purest ore, stone and coke obtainable. "Use of Manganese Alloys in Open-hearth Practice" was studied by MR. S. L. HOYT, in which he described substitutes for 80 per cent ferro. First, recarbonization and deoxidation have been effected simultaneously by use of a cupola-melted mixture of spiegel and pig, analyzing perhaps 6 per cent Mn and 4 per cent C. Second, use a high-manganese charge (scrap, ore and pig iron) and run the furnace with an 80 per cent manganese slag so that at the end the metal retains 0.30 per cent Mn. In such practice the phosphorus is early removed and slagged as calcium phosphate, and the heat finished at a high temperature. Third, silicospiegel can be easily made in the electric furnace from siliceous ores. Low-iron ores are available in the Rocky Mountains, but the high-iron ores so abundant in the Cayuna range are not so desirable, since a much greater quantity of the resulting spiegel is required to do the work. Information as to the use of this alloy is meager, although it is unquestionably suitable for acid casting practice. Three years' experience at one steel plant alternating silicomanganese with ferromanganese plus ferrosilicon shows the former to be somewhat more economical in alloy consumption, and to make for more uniform practice. It is doubtful, however, whether it could safely be used as a furnace addition in basic open-hearth.

EFFECT OF COLD-WORKING AND REST ON RESISTANCE OF STEEL TO FATIGUE UNDER REVERSED STRESS

MESSRS. H. F. MOORE and W. J. PUTNAM submitted a paper on "Effect of Cold-working and Rest on Resistance of Steel to Fatigue Under Reversed Stress." Their results show no marked benefit of a short period of rest on the fatigue strength of steel. Tests also indicate that an increase in strength of medium steel due to cold-working does not necessarily indicate increased resistance to fatigue, while the fatigue-strengths of cold-rolled and annealed steels apparently converge as lower stresses are used, even though the annealing temperature is of large importance. Most excellent moving microphotographs were exhibited, showing the development of slip bands under heavy alternating stresses, together with the progressive extension of incipient cracks. The methods and lenses for making these remarkable pictures were developed by Prof. A. G. ELDRIDGE of the University of Illinois.

Government's Policy in Sale of Surplus Supplies

REPRESENTATIVES of the War Department, the Navy Department and the Geological Survey have had a conference concerning the policies which they should follow. After this conference the Director of Sales, War Department, made the following statement:

1. The fundamental purpose of the conference was to determine, first, what each department of the Government had to sell.
   (a) Any department of the Government desiring material that any other department of the Government may have to dispose of should have an opportunity of obtaining it.
   (b) We should control our methods of selling in such a way as not to permit different departments of the Government to compete one against the other.
   (c) We must dispose of all surplus so as to disturb industrial conditions to the least possible degree.
2. It will first be necessary to give each bureau a record or statement of the surplus on hand.
   (a) We hope to have a more or less complete inventory by Feb. 15.
3. The War Department policy is:
   (a) To dispose of surplus materials to other bureaus of the War Department and other departments of the Government.
   (b) To sell to the contractor in whose possession the material is at a fair price.
   (c) To approach the producers or consumers of a particular material with the idea that they take it over at a fair price and dispose of it at a fair price.
   (d) To dispose of it through ordinary trade channels.
   (e) To put it on the open market.
4. Our general policy is to release small quantities in those instances where it is to the War Department's advantage to release to avoid the payment of storage charges or demurrage, and to accommodate those who desire to buy. In other words, our policy is one of slowly selling our commodities to disturb general market conditions as little as possible. We are not actuated by any desire to dump our surplus on the market without regard to the industry interested. Our general policy is to obtain as much from the sale of this surplus as we can. The trade should distinctly understand that it is not the policy of the Sales Department to sell property to any one for speculative purposes.

Conferences have been held relative to the disposition of surplus brass, copper and lead now on hand in the various bureaus of the War Department. It is expected that an agreement will be made with copper producers that will permit the Government to feed into the market its surplus of copper and brass in such a manner as to obtain fair prices for the Government without upsetting the market.

The situation with regard to lead is even more favorable, as the surplus amounts to only a few thousand tons, which is but a small proportion of a year's output. The same agreement will be made, however, and every precaution will be taken not to disturb the equilibrium of the market and at the same time to obtain the highest prices possible.

War Took All Candidates for Degree

There will be no candidates for the degree of Ph. D. in chemistry at Johns Hopkins University in June on account of the interruption in the work due to the war. However, a number will come up Feb. 22, 1920. The chemistry department of the university is rapidly recovering from the effects of the war and already twenty-one graduate students are devoting full time to chemistry.

Flakes in Alloy Steel

An Outline of Papers and Discussion of This Important Defect Presented at the New York Meeting of the American Institute of Mining Engineers—Divergent Views of Howe, Clayton, Rawdon, Foley and Laney

CONVINCING evidence of the commercial importance of metallographic science was exhibited at sessions of the American Institute of Mining Engineers, where veteran steel makers listened most carefully to technical papers on the origin and control of a relatively new defect known as "flakes." This subject is of much importance on account of the extremely large number of rejections in shops manufacturing nickel and nickel-chromium ordnance material. The control of the defects is most difficult and the conflicting evidence leads to the belief that in some instances at least their appearance in test bars was due to the method of testing and to the personal equation of the inspector. Two important papers on this subject, therefore, attracted much attention. First, C. Y. Clayton, F. B. Foley and F. B. Laney co-operated in presenting a contribution on "Flaky and Woody Fractures in Nickel-Steel Gun Forgings," and H. S. Rawdon presented somewhat conflicting views in his paper entitled "Microstructural Features of Flaky Steel." The whole matter was admirably summarized by Dr. H. M. Howe in his oral presentation of a report by the Steel Ingot Committee, National Research Council. In addition to these gentlemen, Messrs. Unger, Mathews, Stevenson, Speller and others participated in the general discussion.

Flakes are variously known as "flakes," "snow-flakes," "scabs," "lemon spots," "goose eggs," "silver streaks," and are often associated with a fibrous or woody structure in the fracture. Of course, the terminology is not yet precise. For instance, Mr. Rawdon illustrates silver streaks as shown in Fig. 1, and notes that each has in its center a tiny bit of greenish slag. Silver streaks are familiar to many as crystalline fractures due to presence of slags. The other defects are often associated with slag and some men view slag as their controlling cause. But flakes and fibrous structure have been found many times in the cleanest steel. Flakes are most common in chromium and nickel-chromium steels, which are notoriously quite tender under treatment, and in practice have been controlled and eliminated to an extent by well-regulated heating practice. They are supposed to be cracks within the steel itself, and as such would not be found in forged easily welded carbon steels, while a small percentage of nickel in the analysis reduces the weldability markedly. Evidence was cited that their presence is not controlled by the shape of the ingot, casting practice, size of ingot, reheating practice or per cent of reduction. Sometimes a plant would not be troubled with rejections on acount of flaky steel for some time after starting munition manufacture and then flakes would suddenly appear. For instance, Mr. Stevenson cited his own experience that no trouble was encountered during their early operations when they made steel from low-phosphorus scrap. Later as the croppings accumulated the charge was modified to consist of nickel steel scrap and low-phosphorus pig, whereupon flaking became very severe.

FIG. 1. CHROME-NICKEL STEEL WITH SILVER STREAKS IN FRACTURE —ACTUAL SIZE

Macroscopy and Microscopy

Flakes appear in a fracture as bright, silvery spots or areas surrounded by a normal granular field (Fig. 2). Especially is this the case when breaking a specimen which has a refined or hardened grain. It is apparently a spot of more massive or coarsely granular material than its surroundings, but under low-powered magnification there are no sparkling cleavage planes, but the corners and edges are rounded and smooth, suggesting surfaces of squeezed crystals. Clayton believes that the flake passes through the ferrite existing between the sorbitic grains, and partly through the grains themselves—following here the plates of ferrite, producing the Widmanstättian structure commonly observed, and very evident in Fig. 3. Rawdon, on the other hand, thinks that they are remains of the original crystalline faces formed on solidification, which have failed to unite, even during the kneading action of subsequent working.

Presence of the discontinuity known as a flake can be demonstrated after macroscopic etching. Thus, Fig. 4 gives their appearance in a polished transverse surface. Ordinary etching solutions attack the metal near the flake more quickly than elsewhere and leave tiny open cracks. Copper bearing solutions develop them—in fact such media always bring out non-homogeneity such as dendritic crystals or streaks. In a fracture the flakes oxidize less rapidly than the surrounding metal.

Finally, radiographs exhibit white lines which, on breaking the specimen, prove to mark the location of flakes; evidently the metal is more transparent to rays along these planes.

Microphotographs of defective steel always indicate a lack of grain refinement; sometimes this is very striking. Streaks or areas showing variations in grain size may be noted in less infected specimens. Clayton feels that the presence of flakes in exceptionally clean steel is evidence that they are not due to inclusions, while Rawdon apparently leans toward the idea that slag is materially responsible. He finds the filiform ends of coarse flakes to consist of extremely fine films of slag. This point is rather hard to determine, since, if flakes are intercrystalline defects, here, of course, would also be found any slag inclusions or segrega-

tions—an association which might indicate nothing as to the origin of the flakes. If the plane of flake intersects the polishing plane, it appears under high magnification as a black streak around the grain boundaries, thus following any ferrite mesh which exists. Microchemical work at the Bureau of Mines also indicates that the flake areas are higher in phosphorus and carbon than normal metal—differential action by copper-bearing etching reagents always exists along the borders of a flake, as already noted. Rawdon, while admitting the fact that the defect follows grain

FIG. 2. FINE GRANULAR FRACTURE SHOWING 59 PER CENT COARSE FLAKE × 3.5

boundaries, gives photographs such as Fig. 5, which show that a flake has no depth. Clayton and his associates lay much stress on the fact that they always find much evidence of overheating in defective material, such as Widmanstättian structure and spiny ferrite, drawing from this fact a basis of their theory as to their nature and proper control.

Physical Tests

The bulk of the work reported was performed on gun forgings containing 0.38 per cent carbon and 2.9 per cent nickel, with or without a small amount of chromium. When loading a defective test bar of this composition in tension, small cracks develop on the surface normal to the pull. This has led to the widespread idea that flakes are incipient cracks, a conclusion which is hard to reconcile to the unchanged elastic limit shown in the attached table.

TABLE I—PHYSICAL PROPERTIES OF GUN FORGING

	Minimum Specifications	Good Bars	Average of 182 Flaky Bars
Tensile strength	95,000	101,580	97,282
Elastic Limit	65,000	68,260	68,120
Elongation	18%	19.4%	11.6%
Reduction in area	30%	37.5%	20.5%

NOTE—The elongation and reduction in area of the flaky bars are extremely variable, depending upon extent of the defects at the breaking point.

Dr. Howe suggests that the constant elastic limit may be explained thus: Suppose a flake to be an internal area of small strength normal to the pull. The absolute value of the elastic limit would then be reduced according to the area of this reduced section. But as the flake has no depth, the elongation caused when this weak section passes its proportional limit is but a fraction of a thousandth of an inch. No contraction in area is possible in metal strongly supported on all sides, and therefore the extra stretch is not detectable to the extensometer, which naturally is not affected until the specimen gives over a considerable length.

Woody structure appearing in fractures is thought by Messrs. Clayton, Foley and Laney to be much different from flakes, and to emanate from the original dendrites in the ingot. Forging or rolling will elongate these crystals into parallel longitudinal lines giving very low transverse ductility. Such laminated structure is very persistent, annealing for days being required for its elimination. If this be a true explanation of woody structure it may evidently be cured by variable rotation of the ingot, which has been proved to reduce columnar solidification.

Are Flakes Formed During Reheating?

Clayton then proceeds to discuss the possible causes of flakes. First, they may be due to foreign inclusions (which possibility was disposed of above). Second, gas inclusions and cavities may be responsible—an attractive hypothesis which warrants much further investigation. Third, their association with ferrite may indicate them to be due to a local decarbonization resulting from churning in of oxide films formed on pouring. However, extremely few oxide inclusions were found. Fourth, the local segregation of non-ferrous elements to be expected at crystalline boundaries may be responsible for flakes. This is a contributing cause of low-melting areas, postulated by Clayton's hypothetical explanation. Fifth, the shape of the ingot and

FIG. 3. MICROSTRUCTURE OF FIG. 2. FERRITE ROUGHLY OUTLINING PREVIOUSLY EXISTING COARSE NETWORK. × 260

the forging dies does not seem to have much influence. Sixth, flakes may be ruptures in the ingot caused by the differential coefficient of expansion in heretogeneous metal. This is approximately Rawdon's idea, he being ably seconded by Dr. Howe. Lastly, the theory which appeals most to Clayton and his associates is that flakes are due to overheating and non-uniform heat preparatory to forging.

Their experience with shop conditions leads them to believe that forging these special steels is ordinarily done at too high a temperature. For instance one

poorly designed heating furnace was run at 1370 deg. C. at the hot end, producing 70 per cent rejections in steel forged from this temperature, but much better results from the cooler portions of the hearth. If the billet starts too hot, it will be finished at too high a heat, giving a typically coarse grain always accompanied by Widmanstättian structure (Fig. 6). On the other hand with a light reduction under the hammer the temperature can be kept as low as 1040 deg. C., with a resulting structure shown in Fig. 7, and a total absence of Widmanstättian lines or other evidences of burning even under high magnification.

From this basis Clayton ascribes flakes to be ultimately due to slow diffusion of ferrite. In heating coarse-grained hypo-eutectoid steel the first transformation occurs at Ac_1 where pearlite areas revert to austenite of eutectoid composition. Alpha iron envelopes are absorbed at $Ac_{2,3}$ but owing to slow diffusion the resulting austenite is heterogeneous even upon superheating, retaining a high-carbon core where previously was the center of the larger pearlite grains. Here is where fusion starts, and in forging these plastic spots are flattened out, persisting as films and boundaries to which excess ferrite is precipitated. Sorbitizing does not affect this film, and on breaking the specimen exhibits flakes. Thus the authors recommend that tender forgings be heated no higher than the solidus at eutectoid composition, or 1220 deg. C.

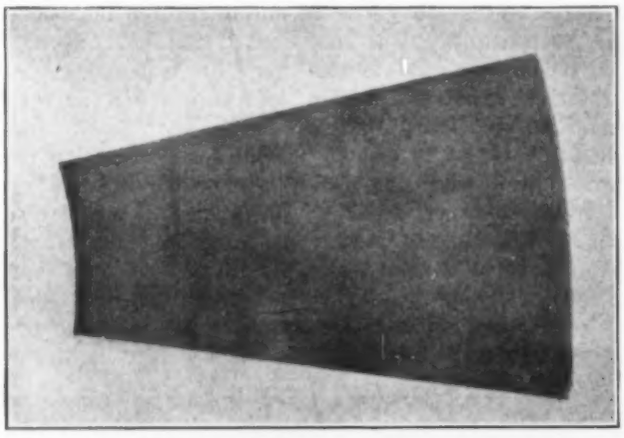


FIG. 4. FLAKES IN POLISHED DISK OF NICKEL-STEEL. ACTUAL SIZE

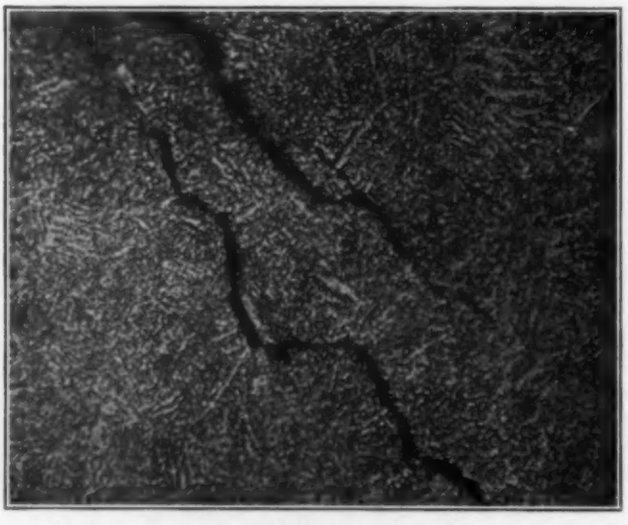


FIG. 5. FLAKES IN HEAT TREATED NICKEL-STEEL FORGING. × 500

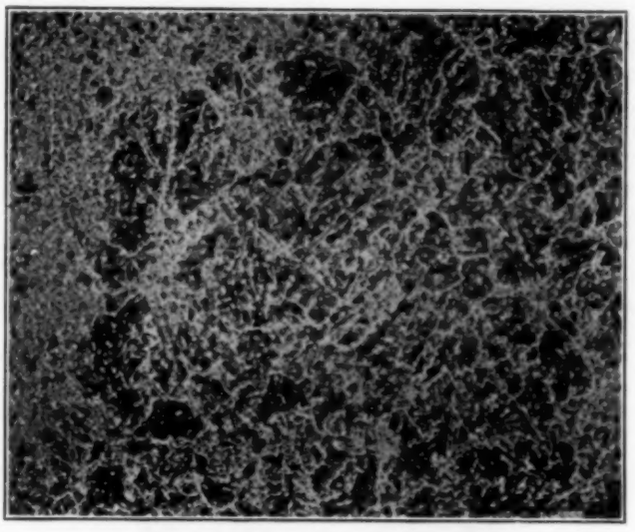


FIG. 6. IMPROPERLY FORGED BAR. × 6

Are Flakes Formed During Solidification?

Dr. H. M. Howe took issue with this theory, which in effect is that the previously solid metal developed, on pulling, a flake at segregated iron, phosphorus or sulphur spots. He supported the idea that the flake is the result of an old unwelded internal crack, deformed somewhat in forging, which opens up and becomes visible upon straining. Clayton's theory does not account for the fact that flakes are habitually ranged in a diagonal direction in square ingots, one-third the way from outside to center, and in a tangential direction in round or octagon ingots. Now if flakes were due to burning during reheating, they should occur in the outer portion of the ingot where it is hottest, assuming that the impurities which cause low-melting spots are not localized during solidification. Furthermore, flakes appear in steel whose heat treatment has never exceeded 900 deg. C.

FIG. 7. PROPERLY FORGED BAR. × 6

Flakes are notoriously connected with tender steel, of the chromium, chromium-nickel, nickel, or chromium-

carbon varieties. Naturally, then, flaking disappeared in certain alloys as the nickel was reduced, and this composition was then found to be amply good for many uses. Again, killing the steel in the furnace increases its compactness, and therefore its tenderness; consequently this metallurgical practice caused more flakes. If such be the case, sound practice demands that this tender steel be humored and so cast that cooling stresses be not excessive; in other words use round molds, strip as soon as the walls are strong, and cool at an intermediate rate by burying in ashes. This lessens the number of flakes enormously, although it should increase the interdentritic segregation.

When Flaking Should Occur

There are three tender stages in the manufacture of a piece of metal, and flaking should occur at one of them. First in the mushy stage of early solidification, the outer walls of the ingot may crack and the fusible portion bleed. This should leave flakes with dendritic sides, as is shown in blow holes or pipes. But this is not their condition, and probably flakes are not formed so early. Second, at a blue heat, moderately below recalescence. Now the outer shell is contracting, while an inner lining just at the recalescent point expands suddenly, throwing large tension stresses into outer metal. The common occurrence one-third the way to the center also suggests that this is the most likely origin. A final tender stage in the history of a piece is when quenching the finished forging. Failure at this point, however, produces the well-known hardening cracks, which are flat breaks, with no white spots; fine crystalline because fine grained.

Hence Howe agrees with Rawdon in his contention that flakes originate in the ingots of tender alloy steels as intercrystalline shrinkage cracks, probably intensified by inclusions and segregations. They persist throughout forging, not being welded, and on straining, reappear with bright surfaces representing the deformed surface configuration of the original crystals. They can consequently be controlled by careful casting, soaking, reheating and heat-treating practice.

Prize Essay Contest in Industrial Economics

The National Industrial Conference Board announces a prize of $1000 for the best monograph on any one of the following subjects:

1. A practicable plan for representation of workers in determining conditions of work and for prevention of industrial disputes.
2. The major causes of unemployment and how to minimize them.
3. How can efficiency of workers be so increased as to make high wage rates economically practicable?
4. Should the State interfere in the determining of wage rates?
5. Should rates of wages be definitely based on the cost of living?
6. How can present systems of wage payments be so perfected and supplemented as to be most conducive to individual efficiency and to the contentment of workers?
7. The closed union shop versus the open shop; their social and economic value compared.
8. Should trade unions and employers' associations be made legally responsible?

Full details concerning the contest can be secured by addressing Magnus W. Alexander, managing director, 15 Beacon St., Boston, Mass.

Import and Export Statistics

The bureau of foreign and domestic commerce of the United States Department of Commerce announces the following import and export figures for the month of December, 1918.

IMPORTS OF TIN BARS, BLOCKS, PIGS, ETC., BY COUNTRIES AND DISTRCTS

Countries	Lb.	Value	Districts	Lb.	Value
England	179,662	$133,116	New York	768,973	$620,051
Mexico	748	578	Pittsburgh	392,000	299,706
British India	112,036	83,035	San Francisco	2,788,507	1,900,061
Straits Settlements	4,498,206	3,197,604	Washington	706,370	478,925
Dutch East Indies	114,689	89,931	Dakota	112,076	79,534
Kongkong	288,037	203,619	Chicago	726,468	522,053
Australia	693,685	490,666	Ohio	168,036	124,081
			St. Louis	224,633	174,138
Total	5,887,063	$4,198,549	Total	5,887,063	$4,198,549

EXPORTS OF TIN PLATE, TERNE PLATE AND TAGGERS TIN BY COUNTRIES

Countries	Lb.	Value	Countries	Lb.	Value
France	122,492	$8,284	Peru	135,000	$25,200
Italy	1,773,480	163,232	Uruguay	4,664,916	371,502
Canada	8,229,567	648,099	Venezuela	128,686	13,228
Panama	1,200	123	China	367,224	42,090
Mexico	99,687	11,042	British India	24,200	2,050
Newfoundland and Labrador	99,700	9,801	Dutch East Indies	37,021	2,484
Other British West Indies	460	64	Japan	507,556	61,675
Cuba	894,740	72,974	Philippine Islands	83,000	7,201
Argentina	13,219,016	1,151,934	British South Africa	116,798	5,973
Brazil	1,508,755	154,878			
Chile	617,299	98,735	Total	32,795,797	$2,863,141
Paraguay	165,000	12,572			

IMPORTS AND EXPORTS OF GLYCERINE

IMPORTS:	Lb.	Value	Countries	Lb.	Value
Total Imports	78,239	$28,237	Trinidad and Tobago	50	32
EXPORTS:			Cuba	3,000	1,974
Countries			Dutch West Indies	100	74
Italy	253,242	124,724	French West Indies	12	10
England	195,888	113,615	Haiti	54	45
British Honduras	10	10	Dominican Republic	60	42
Canada	218,706	126,762	Bolivia	110	91
Costa Rica	153	114	Chile	1,300	878
Guatemala	111	109	Peru	475	387
Honduras	9	13	Venezuela	501	352
Panama	2,283	1,426	China	50	35
Salvador	30	21	Dutch East Indies	105	73
Mexico	1,112	840			
Barbados	100	70	Total	677,471	$371,705
Jamaica	10	8			

UNITED STATES EXPORTS OF CAUSTIC SODA AND SODA ASH, BY COUNTRIES

	Caustic Soda		Soda Ash	
Countries	Lb.	Value	Lb.	Value
Denmark	800,000	$40,000	70,330	$3,125
Norway	.....	.....	2,025,734	74,099
Spain	1,334	92	.....	.....
Sweden	.....	.....	1,711,115	53,363
Bermuda	347	25	560	29
Canada	1,165,722	58,541	6,334,049	165,630
Costa Rica	27,000	1,620	17,500	925
Gautemala	1,400	84	1,200	48
Honduras	.....	.....	50,900	2,001
Nicaragua	35,775	2,299	2,000	100
Panama	96,655	5,062	560	182
Salvador	41,040	2,362	.....	.....
Mexico	1,562,567	85,397	246,481	7,616
Jamaica	2,500	125	336	7
Trinidad and Tobago	84	6	8,000	156
Other British West Indies	400	215	250	5
Cuba	523,362	22,885	1,047,405	14,015
Virgin Islands	.....	.....	600	20
Dutch West Indies	26	7	.....	.....
French West Indies	1,025	67	.....	.....
Dominican Republic	84,055	3,939	.....	.....
Argentina	110,317	5,940	146,398	2,738
Bolivia	54,000	1,574	300	10
Brazil	779,891	43,487	468,910	15,108
Chile	232,925	13,135	110,768	3,507
Colombia	36,000	2,000	9,600	290
Ecuador	50	6	.....	.....
Peru	604,329	30,243	25,350	832
Uruguay	3,864	173	45,640	569
Venezuela	191,883	10,249	145,100	4,715
China	527,580	35,355	273,890	8,250
Japanese China	149,350	8,512	.....	.....
British India	62	22	.....	.....
Dutch East Indies	251,600	16,770	207,600	9,869
Hongkong	.....	.....	15,000	750
Japan	1,202,371	71,947	7,805,813	275,284
Australia	39,600	2,200	1,161,538	48,028
New Zealand	.....	.....	12,000	580
Philippine Islands	207,245	10,001	1,000	63
Total	8,734,359	$474,340	21,945,927	$691,914

Linseed Production in Argentina

During the war enormous quantities of linseed were required to produce the oil for ship paint, camouflage material and rainproof equipment. Argentina, possessing the largest linseed area of any country, played an important part in supplying this demand. About 3,000,000 acres are devoted to linseed, while the corresponding area in the U. S. is only 2,000,000 acres.

The official estimate of the 1919 crop gives the total production as 705,000 tons, the exportable surplus being estimated at 679,000 tons, or about 29,000,000 bushels. During 1918, the United States received practically two-thirds of all the linseed exported from Argentina. On Dec. 5, 1918, the War Trade Board issued a ruling (W.T.B.R. 376) modifying the restrictions which had been placed upon the importation of linseed in July, 1918, to permit the licensing of imports from the River Plate districts (Argentina and Uruguay) of not to exceed 15,000 tons (635,000 bushels) for each of the months of January, February, March and April, 1919, allocation to be made by the War Trade Board.

The linseed requirements of the United States for the 1918-19 fiscal year were given as 26,000,000 bushels.[1] The supply from the American Northwest is given in the January official estimate as 14,657,000 bushels. This means that more than 11,000,000 bushels must be obtained from Canada, India and Argentina.

One of the most interesting developments in the attempt to increase the domestic utilization of the linseed crop has been the discovery that linseed straw is the most practical material for the production of grain bags. The shortage of warehouse space has made imperative the use of large numbers of bags for storing the wheat crops. A domestic source of supply has apparently been found in the 5,000,000 tons of linseed straw available annually, since experiments with the fiber indicate that it is suitable for the manufacture of bagging and binder twine also.

Important Meetings of Chemists and Electrochemists

The American Chemical Society will hold a "Victory Meeting" at Buffalo April 7 to 11. Tentative plans for the program include special consideration of the protection of American chemical industries and the necessary legislative action to secure such protection. Arrangements are being made for visits to plants of important Buffalo manufacturers and for a comprehensive view of the chemical industries of Buffalo and Niagara Falls. Headquarters will be at the Hotel Statler and sectional meetings will be held at the Technical High School.

The American Electrochemical Society will hold its annual meeting in New York April 3 to 5. The feature of this meeting will be a symposium on released information regarding war work. The censorship on scientific information which was enforced during the war has been largely raised and as a consequence it is anticipated that a great deal of valuable information can now be released. The sessions will be held in Rumford Hall, the Chemists' Club.

[1]Report of Linseed Oil Committee of the National Paint, Oil and Varnish Association at the convention held in Boston Dec. 2-4, 1918.

Industrial Use and Limitations of Respirators, Gas Masks and Oxygen Breathing Apparatus

DURING the last year the Bureau of Mines, Department of Interior, has received many inquiries regarding the use of Army gas masks in the industries for protection against poisonous and irritating gases. These inquiries show a general belief on the part of the public that this type of mask will protect the wearer under all conditions against any gas whatsoever, even in absolutely irrespirable air to the exclusion of the more cumbersome mine rescue breathing apparatus. This erroneous belief will no doubt be further confirmed by millions of discharged soldiers who have been trained in the use of the gas mask and have been taught that it gives them absolute protection against all gases used in warfare or likely to be used. These men will not realize that out in the open air of the battlefield the percentage of gas in the air can never be anywhere near as large as may occur in the confined spaces of a factory operation. A mask may afford complete protection under outdoor conditions and break down at once when used indoors where a gas container has burst and filled the room with a greater concentration of gas. It must also be remembered that the absorbents in the Army respirator, which filter out the poisonous gas, are specially designed for the gases used in warfare, and as a matter of fact do not protect against the more common industrial gases as, for example, illuminating, natural, producer and blast furnace gas.

The Army gas mask never should be used in mines, because of the uncertainty there is of the kinds and amounts of gases in the atmosphere and liability of insufficient ogygen to support life.

In view of these limitations of the Army gas mask, which, if not realized, will lead to serious accidents and fatalities, the Bureau of Mines is issuing this brief statement of the industrial use and limitations of the several dust respirators, gas masks and ogygen breathing apparatus.

Dust Respirators

Protection from dust and liquid mists is obtained by the use of a simple dust respirator, which removes these particles by means of a filter of moist sponge, cotton or wool pad, porous paper or even a very fine mesh metallic gauze. The respirator may enclose the mouth and nose only, or it may be combined with a face mask containing eye pieces if the eye must also be protected. The simple "pig snout" respirator containing a moist sponge has been on the market for years. It is highly uncomfortable to wear, rather insufficient for removing fine dust, and most workmen perfer to tie a large handkerchief over their nose and mouth. Some improvement has been made in recent years, but on the whole a really efficient and comfortable dust respirator that workmen will wear continuously is yet to be devised. On account of the urgent need of such a device for safeguarding the health of workmen in the mining and metallurgical industries, the Bureau of Mines has undertaken a study of dust respirators with a view to obtaining as satisfactory a model as possible.

The Army gas mask consists of a face piece of rubber and cloth fabric, containing eye pieces and connected by means of a flexible rubber tube to a canister containing charcoal and soda-lime for filtering out the poisonous gas from the inhaled air. The canister is supported in a knapsack slung from the neck.

The Army gas mask is by no means the unusual protective appliance that it is popularly believed. It does not afford universal protection against all gases, nor can it ever be used safely in low oxygen atmospheres. It furnishes no oxygen to the wearer and can only remove comparatively small percentages of poisonous gas from inhaled air, usually less than 1 or 2 per cent. Higher percentages will immediately penetrate the canister and "gas" the wearer. The standard Army gas mask will furnish protection against percentages not exceeding 2 per cent of the following gases in air: Sulphur dioxide, hydrogen sulphide, chlorine, carbon bisulphide, nitrogen peroxide, aniline vapor, benzyl bromide, benzyl chloride, chloracetone, chlorpicrin, hydrogen chloride, phosgene, sulphur chlorides, xylyl bromide, stannic chloride, titanium tetrachloride and silicon tetrachloride.

It will be seen from the above that the field of usefulness of the Army mask is confined to certain of the chemical industries, around smelters and roasters where sulphur fumes are given off and in the industries using chlorine and bleaching powder. The Army canister also contains cotton filter pads which remove irritating and poisonous dusts, which increases its usefulness around smelters where sulphur and arsenic fumes must be removed.

The Army mask furnishes no protection whatever against carbon monoxide. This is the poisonous constituent of blast furnace, producer and illuminating gases, and of mine gases after fires and explosions in coal mines. Carbon monoxide is also likely to be present in ordinary fire-fighting conditions met by fire departments. Moreover, in all of these cases there is likely to be a deficiency of oxygen. Therefore, for adequate protection against these conditions the oxygen breathing apparatus must be used, and reliance on the Army mask may be fatal.

Ammonia is another gas that will penetrate the standard Army canister. However, a special chemical may be placed in the Army canister which will adapt it for use around refrigerating plants.

Oxygen Breathing Apparatus

The self-contained oxygen breathing apparatus can never be displaced by the gas mask for use in atmospheres deficient in oxygen. Such atmospheres are encountered in mine rescue work, in gas mains, blast furnace stoves, gasoline tanks, etc. Aside from the lack of oxygen, carbon monoxide is also present, for protection against which the Army mask is useless.

The oxygen breathing apparatus must also be used instead of the Army gas mask wherever there are large quantities of irrespirable or poisonous gases, as for example, in entering a gasoline tank containing some residual liquid, or similar tanks, towers and other closed spaces. The concentration of vapors produced by volatile liquids in closed containers is too high to be entirely removed by gas mask absorbents. The only recourse in such cases is a self-contained appliance in which the wearer does not breathe any of the irrespirable atmosphere.

Importance of Taking Expert Advice

Owing to the many factors entering into the use of protective respiratory appliances, the importance of competent advice on the selection and use of such appliances cannot be overestimated. The fact that the Army and Navy used gas masks has been widely disseminated and its significance is likely to be misunderstood, especially by men who have had some training in their use. It also should be made known that both the Army and Navy used the oxygen breathing apparatus in its appropriate place.

In connection with the Bureau of Mines work of safeguarding the health of miners and workmen in the metallurgical industries, a general investigation of respirators, gas masks and breathing appliances is being undertaken at the Pittsburgh Experiment Station of the Bureau. This research will be conducted by experienced chemists and engineers who had charge of gas mask research in the Bureau's war gas investigations and subsequently in the Research Division of the Chemical Warfare Service, U. S. A.

Pittsburgh Experiment Station,
Bureau of Mines.

Summary of the Tin Situation by the Geological Survey

The tin situation in this country continues inactive and unsettled, caused mainly by the large stocks in the hands of the Government and of large consumers, and the restrictions on imports, except ore purchases by domestic smelters. In order to stabilize the erratic market which was so prevalent during the first half of 1918, announcement was made in September of the inter-Allied control. By this arrangement, buying in the primary markets was done by Government agencies, and no tin could be imported into the country except through the United States Steel Products Co. From the inter-Allied purchases there was allocated to the United States about 10,000 tons, at a price approximately 72½c. per pound f.o.b. Eastern points.

The signing of the armistice found the Steel Products Co. with practically the entire allocation on hand, besides large stocks in the hands of the principal consumers. Until these stocks are absorbed and restrictions removed from importation, the tin situation is likely to remain uncertain. How long it will take to absorb these stocks will depend mainly on the condition of business and the production of the domestic smelters, which are in an advantageous position, inasmuch as they can purchase their ores in an open market at considerably below the fixed price of tin in this country. They are in a position, therefore, to sell their product at a few cents under the fixed price, giving them the control of the market and at the same time insuring large profits.

It is estimated that the consumption of tin will be largely curtailed during 1919, and probably will not exceed 3500 tons per month. It is thought the requirements can be easily supplied by domestic smelters using foreign ores, supplemented by the stocks now on hand.

Concrete as a Chemical Engineering Material*

By Maximilian Toch

IT may truly be said that this is the age of concrete. What progress would our new factories have made after this country went into the war, when steel and iron were unobtainable, had it not been for the ability to use portland cement in its place? It is no criticism to say that portland cement concrete is an unfinished material when used in the erection of chemical works. No floor in any factory will last very long made of portland cement and sand, unless it is treated in some manner. I have seen instances where the concrete foundations of vinegar tanks were decomposed until they resembled a material like cheese, owing to the solvent action of acetic acid. I have seen foundations of motors and machinery where the oil drippings disintegrated concrete in a relatively short period. I could cite many more cases, but these will suffice. There are a great many materials which preserve portland cement construction against acids, alkalis, oil and saline solutions, and there is no one material which may be regarded as a panacea for all the defects of concrete. When the defects of concrete are mentioned I must again impress upon you that I am not criticising the material; but a concrete sidewalk is about the only cement construction of any magnitude that I can recall which needs no treatment to make it waterproof, wearproof and weatherproof.

Defects of Concrete Construction

Take the case of a concrete floor in a room where there is delicate machinery. In a short time the particles of sand and broken stone which form the composite of the concrete became loosened, float around in the air and lodge on the contact points of this delicate machinery. Take the case of foundations in chemical works, where acids and alkalis drip on the foundations. Take the case of concrete foundations of factory buildings on a waterfront, where niter cake and sludge acids are discharged in the stream, and you will soon erode the concrete foundations. All this is due to a very simple chemical problem. Portland cement has been described so often that I do not need to go into its chemical composition other than to say that when it is mixed with water it generates lime and the lime forms a glutinant material which binds the particles together. This same condition is identical in all mortars, and the common, ordinary lime mortar of building material, while it contains a much greater amount of lime than portland cement, is weaker in every respect than portland cement itself. Lime is slightly soluble in plain water and is relatively more soluble in salt water. This accounts for the disintegration of portland cement at the seashore. Any acid, no matter how weak, forms a chemical combination with lime; when the lime is attacked in portland cement the structure crumbles.

There are a large number of methods used for the protection and preservation of portland cement; and, as I have said before, there is no single method applicable in every case. Our Government and every other Government have had an enormous amount of trouble in building dry docks which would withstand sea water, even though some of these dry docks were faced with granite or other building stones, because the building stones must be cemented together with a mortar containing lime in some form. A very interesting case developed in one of the large dry docks in New York Harbor, where the sea walls were waterproofed with an integral material but where the bottom was not waterproofed, and after a lapse of five years the solvent action of the salt water attacked the bottom, but left the sides untouched. But the greatest problem of all is the construction of foundations, vats and storage buildings for chemical materials which should be proof against acids and alkalis under normal conditions. Up to within two years ago no one ever thought of building storage warehouses of concrete for the storing of large quantities of niter cake. This material, as you know, is an acid sulphate of sodium containing as high as 30 per cent. of free sulphuric acid, and yet it has been possible to build successfully such a storage building which would house niter cake and not attack the walls and floors made of concrete. In a case like this, it is necessary to use two methods—one, an integral method, and in addition to this, a surface coating which will be acidproof.

Concrete Tanks for Storage of Oil

The great scarcity of boiler plates for the building of large tanks forced our own Government to build tanks for the storage of fuel oil, of concrete; and, as there are two kinds of fuel oil—the very heavy Maltha, of the West Coast, and the thinner type of Pennsylvania and Ohio—it soon becomes obvious that the Maltha or Western type could be stored in any kind of a pit made of any material, but the Eastern oil would soon destroy the crystalline structure of portland cement and leak through. So it became essential to find methods of making concrete oilproof, and in this again the integral plus the surface coating method are essential.

To use a very homely comparison, and one that is somewhat graphic, I must frankly state that unless the engineers' specifications are strictly carried out, failure will inevitably result and no material should be blamed for a lack of supervision. To write a specification for concrete and chemical engineering construction is not an easy matter, and unless the inspector is intelligent and watchful, failure may result. I always think, in this connection, of the case of the man who went into a restaurant and called the waiter, and explained to him the kind of a steak that he wanted. He insisted that the steak should be an inch and a half thick and six or seven inches long, and it should be grilled over a coke fire for forty-five minutes at a distance of one foot from the fire; that after it was grilled it should be smothered with mushrooms and onions and then allowed to seep for ten minutes and placed on a hot plate and served to him. The waiter, after having carefully listened to these orders, walks over to the kitchen and yells "One steak." This is a very fair example of how many specifications are carried out and how engineering materials are blamed for the lack of carrying out the orders carefully.

*Address delivered before the American Institute of Chemical Engineers, Chicago, Jan. 16, 1919.

It is not my purpose to give any specifications for the various types of waterproof and chemicalproof materials now on the market for the preservation of portland cement concrete; but suffice it to say that there are not very many materials on the market which are completely meritorious, and the negative attitude in times gone by of the Bureau of Standards is to my mind largely due to the fact that several materials have been exploited which have been without merit. In fact, unless a man is scientifically trained and knows the reactions that may take place when various materials are subsequently stored or come in contact with concrete, he cannot devise a material which shall fulfill the purpose, but fortunately, as these materials are found out and found wanting, they from time to time disappear from the market, but in the meantime they harm directly and indirectly those compounds which have shown and proven their efficacy. I have a case in mind where one of the foremost architects in the United States has condemned all materials on account of failures which he has seen made with materials which should not have been used.

Types of Waterproofing Used in Chemical Industries

The following, in a general way, are the types of waterproofing used in the chemical industries:

First—The integral type, which is used in the form of a dry powder, and the action is to densify the concrete, give it colloidal properties and to lubricate the mass while pouring. There are a large number of paste aqueous materials on the market, some of which are a kind of soap. Generally speaking, these soaps are to be avoided.

Second—The next type well known is the varnish type, which depends for its reaction on acid resins and has proved itself waterproof, oilproof and wearproof.

Third—The third type is the fluo-silicate type, which in conjunction with the acid resin type or the bituminous coating type, where a proper bond can be effected, has given most excellent results.

There are, of course, modifications of these types, and I have in mind the building of the first storage building for niter cake large enough to hold a thousand tons, in which the concrete, after two years, has not shown the slightest disintegration. Another modification of this type is used for the building of concrete foundations along waterfronts where the water is decidedly acid and it is quite obvious that unless the concrete is properly treated the solvent action of acid water would erode and dissolve away the concrete in a short time, and yet under proper treatment such foundations have stood up without showing the slightest sign of decay or disintegration, and the manufacturers are all aware of the fact that concrete may be constructed which is proof against acid fumes, and a number of these buildings are all in successful operation.

We must bear in mind that civilization is the great destroyer of our building materials. In the balmy air of southern Italy, where temperature changes are not very great and where the people still burn wood, and very little of that, and that only for domestic purposes, the masonry construction of the Roman Aqueduct has stood for two thousand years without disintegration. The same is true of the masonry construction of Egypt, yet we know that our obelisk, after having stood for twenty centuries in Egypt, began to disintegrate after it was erected in Central Park in New York, due first, to the climatic changes, and secondly, to the sulphuric acid in the air. I had occasion to examine most minutely the Tomb of Perneb after it arrived and was set up at the Metropolitan Museum of Art in New York. This tomb was built 4500 years ago, and the stones were in perfect condition when they arrived, but the atmosphere in New York soon began to produce an excrescence, due entirely to the foreign substances in our atmosphere. The same is true of the monumental buildings of London, where, as long as there were no factories, the great buildings showed no signs of decay, but when London began to burn soft coal and belched sulphurous and sulphuric acid into the air, the building stone and cement construction immediately showed signs of decay and deterioration. This condition is of course amplified by the ordinary fumes in a chemical factory itself, and it is very fortunate that through modern methods of skillful investigation portland cement can be made to resist these conditions. Railway engineers are recognizing this all over the country, and where locomotive blasts belch forth their fumes against concrete bridge arches, the arches are treated so that they will withstand the onslaught of chemical vapors.

Methods of Protection

Briefly summed up, the methods for the protection of concrete against erosion, chemical action, disintegration and decomposition are as follows:

First—The well-known membrane method, which consists, usually, of applying tar, asphalt or other bituminous materials, in conjunction with a membrane such as felt, burlap or textile fabric of any kind;

Second—The brush application on the exterior of a concrete construction of a hydrocarbon material which is neutral;

Third—The brush application of an acid resin which combines with the lime of the concrete and forms an integral material on the surface only;

Fourth—The addition of a dry powder not to exceed 2 per cent, to densify concrete and to make it waterproof;

Fifth—The addition of an integral powder to the concrete, to make it acidproof and alkaliproof;

Sixth—The application of a brush coating or spray of a silicofluoride, which precipitates silica into the interstices or pores of the concrete and makes it proof against oil and water;

Seventh—Coating the concrete structure with two solutions which interact and precipitate and form an insoluble residue which prevents penetration of chemical compounds.

This, in a general way, is the practice of the present day, and sometimes two or more methods are used where the concrete is subjected to extraordinary conditions, but sufficient work has been done on this subject to enable chemical engineers to state with a considerable degree of assurance that concrete, which ten years ago was regarded as unfit as a building material in the chemical industry, can to-day be so manipulated that it has taken its place as one of the best, if not the cheapest, and most enduring material in chemical engineering.

Milling Calculations

A Compilation of Formulas Useful in Determining Extraction of Processes, Efficiency of Machines, Density of Solids, Solutions and Pulps—Notes on Methods of Testing and Microscopic Examination

BY ROBERT S. LEWIS*

IN ORDER to exercise proper control over the operation of milling plants it is necessary to make frequent and regular calculations of mill performance. The extraction made by the plant, by the individual machine or group of machines, and the tonnage treated are the items that most commonly require determination, and these are computed by means of weights and assays. Efficient and economic operation demands that concentrating machines be operated at full capacity and with a uniform rate of feed, but such conditions are seldom if ever attained in practice. As soon as a mill goes into operation the usual tendency is to crowd through it as large a tonnage as possible. Many a plant is handling an overload of from 50 to 100 per cent, if the capacity for which the mill was originally designed is taken as a basis of calculation. It is impossible to prevent choke-ups in pipes and launders, belts jumping off, or the breaking of machine parts. These result in sudden stoppages of feed, and, even though promptly remedied, prevent the maintenance of smooth operating conditions.

COMPUTATION OF EXTRACTION

Skilled as some operators become in judging the performance of a machine, the actual work that it is doing cannot be learned without making tests. For plants using straight mechanical concentration, the calculation of extraction deals with only three quantities: feed or heading, tailing and concentrate. Where the weights and assays of these items are known, the calculation of extraction is quite simple. For plants using a more complicated process, such as concentration followed by the cyaniding of sands and slimes, the computation of extraction becomes longer. The difficulty of correctly sampling certain mill feeds, such as those containing native gold or native silver, is often urged as a sufficient reason for using the method where extraction is based upon the metal recovered and the loss in the tailing. Instead of using the formula

$$\text{Extraction} = \frac{\text{Metal in concentrate}}{\text{Metal in ore}}$$

it is considered that

$$\text{Extraction} = \frac{\text{Metal in concentrate}}{\text{Metal in concentrate} + \text{loss in tailing}}$$

This latter method may be satisfactory from the viewpoint that the operator is concerned not so much with what is in the ore as with what he recovers and what he loses. However, such a calculation does not show the losses that may take place in the various stages of operation, for example, the wasting of valuable solutions and the loss by dusting or through fume and smoke in smelting plants. All quantity estimates are based on dry ore, yet the latter formula would not indicate that a serious error in moisture determination was being made.

Consider the case of a copper concentrator handling 10,000 tons of ore per day. This is reported as dry weight, but suppose an error in moisture determination has been made so that this weight really contains 0.5 per cent of water. Then 50 tons of water is daily reported as ore. This amounts to 1,500 tons at the end of a month and if the ore assays 2 per cent copper, the discrepancy between the amount of copper calculated as coming to the mill and that actually contained in the ore is 60,000 lb. per month. This copper has apparently been lost in the mill, since the copper actually in the concentrate together with that lost in the tailing fails to check the copper in the feed by this amount.

FORMULAS DISREGARDING MIDDLINGS

It is not convenient or always possible to segregate and weigh the concentrate produced each day, but its weight can be calculated, as will be shown below.

Let H = weight of feed. (Generally in dry tons of 2000 lb.)
T = weight of tailing.
C = weight of concentrate.
h = assay of feed.
t = assay of tailing.
c = assay of concentrate.

As the whole is equal to the sum of its parts, we may write

$Hh = Tt + Cc$ and $H = T + C$. Eliminating T,
$Hh = t\ (H - C) + Cc$ or
$H\ (h - t) = C\ (c - t)$, whence

$$(1) \qquad \frac{H}{C} = \frac{c - t}{h - t} = R$$

R is called the ratio of concentration and signifies the number of tons of feed required to yield one ton of concentrate. When this figure has been determined for an ore, it is a simple matter to calculate how much concentrate will be obtained from a given tonnage of ore or what tonnage of ore should be put through the mill to yield a desired weight of concentrate. Thus $H = CR$, or $C = H/R$.

The extraction E is the percentage of total mineral in the ore that is obtained in the concentrate. Obviously $E = Cc/Hh$, but this has the disadvantage of requiring weights as well as assays for its solution. By combining this formula with formula (1) for the ratio of concentration we may write

$$(2) \qquad E = \frac{Cc}{Hh} = \frac{c}{Rh} = \frac{c(h - t)}{h(c - t)}$$

In this formula all weights are eliminated.

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Example: The assays from a copper concentrator are as follows:

Feed	1.6 per cent Cu.
Tailing	0.6 per cent Cu.
Concentrate	16.0 per cent Cu.

Then $E = \frac{16(1.6 - 0.6)}{1.6(16 - 0.6)} = 0.65$, or the extraction is 65 per cent.

When the weights of the feed and tailing or the concentrate and tailing are known, we may write

$$(3) \qquad E = \frac{Cc}{Cc + Tt} = \frac{Hh - Tt}{Hh}$$

Formulas Involving Middlings

In case a middling product is made and must be taken into account, the formulas become more complicated and it is necessary to use both weights and assays[1].

Let M = weight of middling and m = its assay, then, using the same notation as before,

$$(4) \quad E = \frac{Cc}{Hh} = \frac{Cc}{Tt + Cc + Mm} = \frac{Cc(h - t)}{hC(c - t) + Mh(m - t)}$$

$$(5) \quad T = \frac{C(c - h) + M(m - h)}{(h - t)}$$

$$(6) \quad H = \frac{C(c - t) + M(m - t)}{(h - t)}$$

In some cases the interpretation of small scale gravity concentration and flotation tests is rendered ambiguous by a middling product, which would be eliminated in regular operation by being returned to the head of the machine[2]. The value of the clean concentrate and tailing produced would not be affected by the return of this middling. Such an assumption seems justifiable on the ground that the middling is of the same materials as the ore, being merely a mixture of the same constituents found separately in the concentrate and tailing.

An Illustration

Suppose a 10-lb. sample of gold ore assaying 0.895 oz. is concentrated with the following results:

1.15 lb.	middling assaying	0.35 oz.
1.25 lb.	concentrate assaying	6.53 oz.
7.60 lb.	tailing assaying	0.055 oz.

It is desired to calculate the weights of the products and the extraction with the middling eliminated. If R by formula (1) gives the tons of ore required to make 1 ton of concentrate, 1/R is the fraction of a ton of concentrate made from one ton of ore. Inverting formula (1) and substituting the above assays gives

$$\frac{1}{R} = \frac{0.895 - 0.055}{6.53 - 0.055} = \frac{0.840}{6.475} = 0.1297$$

As the assays of the concentrate and tailing remain the same, the total weight of concentrate produced would be $10 \times 0.1297 = 1.3$ lb., and of the tailing $10 - 1.3 = 8.7$ lb. We now have for a sample of 10 lb. of assay 0.895 oz., a concentrate of 1.3 lb., assay 6.53 oz., and a tailing of 8.7 lb., assay 0.055 oz. The extraction can now be calculated by formula (2).

Consider the following flotation test: 500 g. of ore is treated in a test machine for fifteen minutes, the products being a final tailing and a rough concentrate. This concentrate is re-run, giving a finished concentrate and a middling, which is too valuable to run to waste. In practice the middling is returned to the head machine. The data from the test are tabulated below:

	Weight Grams	Assay Per Cent Pb
Feed or heads	500	5.7
Concentrate	31.5	41.0
Tailing	420.0	2.1
Middling	48.5	13.94

From (2) the extraction is $\frac{41(5.7 - 2.1)}{5.7(41 - 2.1)} = 0.666$ = 66.6 per cent.

The relative weight of concentrate, the middling being eliminated, is found from formula (1), inverted, as $\frac{5.7 - 2.1}{41 - 2.1} = 0.0926$, and the total weight is 500 g. $\times$ 0.0926 = 46.3 g.

Where the extraction is calculated from assays, as indicated above, the result is called the "apparent" recovery and is not the "actual" recovery based upon the weights of the ore and concentrate. The discrepancy between the two recoveries is due to errors in sampling and assaying. The above formulas are to be relied upon only in so far as the sampling and assaying are correct. While it is not the purpose of this article to discuss the effect of incorrect assays, the bibliography gives some references to that question.[11,12]

Calculations in Cyanide Practice

In cyanide plants the calculation of extraction is complicated by the number of items that must be considered. For a plant using gravity concentration followed by cyaniding of the sand and slime, the extraction by each treatment can be figured separately and all can be combined into one result. If the extraction by concentration is 30 per cent and an extraction of 75 per cent is made on the 70 per cent of the total mill feed that goes to the cyanide plant, the extraction for the whole mill is 30 per cent + (75 per cent $\times$ 70 per cent) = 30 per cent + 52.5 per cent = 82.5 per cent.

A formula for calculating the extraction where combined processes are used is given below[3].

Let E = per cent extraction;
h = assay of feed; H its weight;
m = assay of concentrate tailing; M its weight;
c = assay of concentrate; C its weight;
d = assay of sand head; D its weight;
f = assay of slime head; F its weight;
d_t = assay of sand tailing; D_t its weight;
f_t = assay of slime tailing; F_t its weight.

Then, $H = C + M$;
$M = D + F$;
$Hh = Cc + Mm$;
$Mm = Dd + Ff$;

$$E = \frac{Cc + D(d - d_t) + F(f - f)}{Hh}$$

To eliminate all weight factors, eliminate M from the first and third equations just above:

$$\frac{C}{H} = \frac{h - m}{c - m}$$

Eliminate C from the same two and F from the second and fourth:

$$\frac{M}{H} = \frac{c - h}{c - m}$$

$$\frac{D}{M} = \frac{m - f}{d - f}$$

Multiplying these two gives

$$\frac{D}{H} = \frac{(c-h)(m-f)}{(c-m)(d-f)}$$

Derive similarly the relation

$$\frac{F}{H} = \frac{(c-h)(m-d)}{(c-m)(f-d)}$$

and substitute the appropriate ratios in the expression for E:

$$(7) \quad Eh = \frac{c(h-m)}{(c-m)} + \frac{(c-h)(m-f)}{(c-m)(d-f)}\left(d-d_t\right) + \frac{(c-h)(m-d)}{(c-m)(f-d)}\left(f-f_t\right)$$

It should be noticed that the formula is the summation of the three extractions made separately by concentration, by sand treatment and by slime treatment.

Equation (7) may be simplified somewhat into the form

$$E = \frac{c(h-m) + \frac{c-h}{d-f}[(m-f)(d-d_t) - (m-d)(f-f_t)]}{h(c-m)}$$

At plants where the continuous counter current decantation process is followed the formulas for computing the extraction depend upon the details of the treatment used. An excellent discussion of this subject is to be found in the trade publication of the Dorr Company of Denver entitled "Continuous Counter Current Decantation."[12a and 30]

Screening Practice

Screening tests are a valuable means of controlling some details of milling operations, but, if due care is not exercised in making the tests and if the results are not correctly interpreted, the information obtained may be very misleading.[47] In order to make informing comparisons of screen tests three requirements should be fulfilled.

1. Screens of the same size of aperture and wire should be used for each test.
2. The same method of screening should be followed in all tests.
3. All tests should be run for the same length of time, and preferably in a mechanically operated screening machine.

The word "mesh," meaning the number of openings per linear inch of screen, has no definite meaning. Obviously, the number of openings per linear inch may remain the same for various screens, each of which is made of wire of a different diameter from that of the others, and yet no two screens would have the same aperture. The importance of using a standard series of screens for testing purposes cannot be too strongly urged, for without such a uniformity of screens, published data of tests are rendered worthless. Screen manufacturers have discussed this matter and a set of standard screens has been recommended.[48] This series is based on a 1-mm. opening with the square root of 2, or 1.4142, as the ratio of the openings of successive sieves coarser than 1 mm., and the fourth root of 2, or 1.1892, as the ratio of the openings of successive sieves finer than 1 mm.

Three methods of screening, with some slight variations, are in common use. They are dry screening, wet screening and what may be called a combination method. For dry screening the desired screens are nested in proper order, the sample to be tested is placed on the top or coarsest screen and the set is shaken for a certain length of time. In wet screening the sample is washed through each screen either by means of a jet of water or else in a vessel of water, the respective sizes remaining on the different screens dried and weighed. This is the most accurate method of screening, but much time is required for making a test. In the combination method, the whole sample is first washed on the finest screen used and both oversize and undersize dried. The oversize is then treated as in dry screening, the material passing the finest screen is added to the undersize made by the washing to obtain the final result. This method saves time as against the wet test and is sufficiently accurate for most purposes. All tests should be continued for the same length of time, usually from 10 to 20 minutes; the most suitable time for any particular ore is found by experiment. During any test some material will continue to pass through the screens, though the shaking is maintained for hours. When working on the screening of cement, the United States Bureau of Standards stops a test when the material passing the screen in a given length of time reaches a certain minimum amount.

For ores that have a tendency to fracture into long prisms or needles violent shaking of the screens may cause many particles to pass through a screen, while a gentle screening of the same ore would give a different result. The finest particles of ore tend to stick on the surface of the larger particles and also to adhere to the wires of the screens. Sometimes this fine material forms into balls and remains on the coarser screens. Wet screening is, therefore, more accurate than dry screening. Shaking in a machine eliminates the personal equation, and thus makes it possible to compare different tests satisfactorily. Duplicate tests on the same material should give practically identical results. Since hand screening necessitates the use of only one screen at a time and a screening machine will take the entire set of screens at one time, machine screening becomes imperative where a large number of tests must be made daily.

The results of screening tests are, at best, only approximations of the truth, but that is all the more reason why the greatest care should be exercised when making them. Screen apertures grow larger as the wires wear; evidently, a badly worn set of screens will not give the same results as a new set. In reporting the results, the various sizes should be tabulated and a curve should be plotted from the data thus obtained.

Screen Efficiency

It is possible to make fairly reliable comparisons of the work done by different crushing or grinding machines by means of screening tests. However, it should be remembered that a single test may be quite unreliable as a basis for judging the performance of a machine. Thus, in checking up the work of a ball or tube mill, the average of a number of tests extending over a long period of time, several months or even a year, is the only reliable indicator of the work that the machine is doing.

In a mill where the crushed ore is separated into various sizes by screens, it may be desirable to conduct tests between different kinds of screens or it may be

necessary to determine how much additional feed a certain screen can handle without seriously diminishing its efficiency. The actual amount of screen undersize in the feed must be determined by careful laboratory screening tests. Call this the "actual undersize." Then run a known quantity of feed through the screen and weigh the undersize produced, calling this the "apparent undersize. Then the efficiency of the screen is the apparent undersize divided by the actual undersize.

A test run on 50 tons of feed gave 10 tons, or 20 per cent, as the apparent undersize. A screening test indicated that the feed contained 30 per cent actual undersize. The efficiency of the screen was, therefore, 0.20 ÷ 0.30 = 0.67, or 67 per cent.

Calculating the Efficiency

It is not always convenient to weigh large quantities of material. By the use of formula (2), the efficiency of a screen or trommel can be calculated from screening tests of the feed, oversize and undersize[4]. If f, u and o be used to represent the respective percentages of feed, undersize and oversize that go through the given mesh, we may write

$$E = \frac{u(f - o)}{f(u - o)} \tag{8}$$

In the above example, screen tests showed that the oversize from the screen contained 12.5 per cent of material that should have passed through the screen, and that there was 30 per cent of undersize in the feed. Assuming that the percentage of undersize in the undersize was 100 per cent (no test made on this material), the efficiency of the screen is

$$E = \frac{100(30 - 12.5)}{30(100 - 12.5)} = 0.667 = 66.7 \text{ per cent.}$$

It may be of interest to know how much of the finest sizes in the feed pass the screen. If too little wash water is being used, for instance, some of the fine material will remain in the oversize. Thus, much 200-mesh material may be contained in the oversize of a 2-mm. trommel. To determine the percentage, make screen tests on the feed, oversize and undersize, using a 200-mesh screen. Then use formula (8).

Feed in Closed Circuit

Machines run in a closed circuit always have some oversize returned. This results in a building up of the quantity of material going to the machine until it may reach several times the amount of the original feed before equilibrium is established. Unless this possibility is recognized at the time of installing the machine, a serious overload may be developed. The exact value of the ultimate feed cannot, of course, be accurately estimated beforehand. Crushing tests on the ore will give some idea of the percentage of original feed that will be returned as oversize, but, as the amount of feed increases, conditions of crushing change and the percentage of oversize made does not remain constant. Assuming, however, that the percentage of oversize remains constant, the ultimate feed would be the sum of the infinite geometrical series $x + xr + xr^2 + xr^3 + \ldots = \frac{x}{1 - r}$

where x is the original feed and r is the percentage of oversize. Suppose that a test on a set of rolls indicated that 60 per cent of the feed would be returned as oversize. On a basis of 20 tons per hour the theoretical ultimate load is then $\frac{20}{1 - 60 \text{ per cent}} = \frac{20}{0.40} = 50$ tons per hour.

Split Feeds

Screen tests may be used to show how a product is being split into two parts[5]. At some concentrators, the tailing is sent to a classifier, the spigot product going to make a dam and the overflow going into the pond to be settled.

Let T = total tailing.
P = part going to the pond.
D = part going to the dam.

If a screen test is made on the tailing, say on the 100-mesh size, the respective percentages may be designated by the symbols t_{100}, d_{100} and p_{100}.

For unit weight, $D + P = 1$

Also $Dd_{100} + Pp_{100} = t_{100}$

Eliminating P we have:

$$D = \frac{t_{100} - p_{100}}{d_{100} - p_{100}} \tag{9}$$

Example: At a certain plant screen tests gave 44.4 per cent, 75.2 per cent and 3.1 per cent as the respective values for t_{100}, d_{100} and p_{100}. Substituting in (9), $D = \frac{44.4 - 3.1}{75.2 - 3.1} = 57.3$ per cent to dam, and consequently 42.7 per cent to the pond.

This formula applies equally well where one product is split into two parts or where two are combined into one, but it is reliable only when there is a wide difference between the percentages of the two parts. Thus, if p_{100} and d_{100} were equal or nearly so instead of being 75.2 and 3.1 per cent, the formula would not give correct results. However, this point is not of great importance, since, in most cases to which it would apply, there would be ample difference between the products.

Tonnage of Mills

The large capacity of modern ball and tube mills makes it difficult, if not impossible, to cut out and weigh samples of the feed and discharge. Also it is very hard to determine correctly the percentage of moisture in the pulp. Consider the case where the discharge from the stamp mill battery is screened or classified, the oversize passing to a tube mill working in closed circuit with a drag classifier. The total tube mill tonnage, including returned feed, may be found in terms of the battery discharge as follows[6 and 7]:

Let a = per cent of minus any given mesh in battery discharge.
b = per cent of minus any given mesh in tube mill feed.
c = per cent of minus any given mesh in tube mill discharge.
d = per cent of minus any given mesh in classifier overflow.
B = battery tonnage (dry)
T = tube mill tonnage (dry)

Then $aB + cT = bT + dB$, whence

$$\frac{T}{B} = \frac{d - a}{c - b} \tag{10}$$

which expresses the ratio of tube mill to battery tonnage.

Another method of computing tube mill tonnage is based upon the material in the battery discharge that

does not show in the tube mill product[9]. For example, take the following case:

DATA FROM SCREEN TESTS (CUMULATIVE)

Mesh	Battery Discharge, Per Cent	Tube Mill Feed, Per Cent	Tube Mill Product, Per Cent
10	10.3	5.4	.....
14	20.3	10.6	.....
20	30.5	15.9	.....
28	41.8	21.8	.....
35	49.5	26.7	1.0
48	56.6	33.2	4.1
65	62.2	41.3	10.6
100	68.2	61.3	30.6
150	74.8	85.7	59.2
200	78.8	93.5	71.9
—200	100.0	100.0	100.0

There is 41.8 per cent of total battery discharge which does not appear in the tube mill product. It had been determined that the mill received 62.5 tons of battery discharge per day. Then 41.8 per cent of 62.5 = 26.12 tons. But this represents 21.8 per cent of the tube mill feed. Therefore the total tube mill feed is 119.8 tons. Also 119.8 tons — 62.5 tons = 57.3 tons as the amount returned to the mill by the classifier. By formula (10)

$$\frac{T}{B} = \frac{0 - 41.8}{0 - 21.8} = 1.91.$$

Since B = 62.5, T = 62.5 × 1.91 = 119.4 tons. The same screen size, 28 mesh, is used in both cases, though any other size should give the same result by the formula if the screen tests have been accurately made.

Formulas for Pulp

The introduction of the flotation process and the methods of treatment used in cyanidation and other hydrometallurgical processes all emphasize the importance of carefully controlling the dilution of the liquid pulp. Most of the following formulas dealing with pulp calculations are from an article by W. J. Sharwood[10].

The weight of solid in a vat filled with a uniform liquid pulp can be determined by drying and weighing a known volume. By proportion, the weight of the entire volume can be calculated. If the specific gravity of the pulp and the density of the dry solid are known, the weight of dry solid per cubic foot as well as many other factors can be computed by the following formulas.

Let d = density or specific gravity of the dry solid (ore, slime or sand)

p = specific gravity of the pulp (weight of 32 cu.ft. in tons)

S = percentage by weight of dry solid in the pulp

R = water ratio of pulp (tons of water per ton of dry solid)

V = volume percentage of solid pulp (cu.ft. solids in 100 cu.ft. of pulp)

F = solid factor, or tons solid in 100 fluid tons (3,200 cu.ft.) of pulp

$k = \frac{100d}{d - 1}$, a constant for any one solid. Used to facilitate computations.

Then the total weight of pulp containing unit weight of solid is R + 1, and the volume of this amount is $R + \frac{1}{d}$, whence the specific gravity of the pulp is $p = \frac{R + 1}{R + \frac{1}{d}}$ as given in formula (12) below. Explicit

TABLE I—FORMULAS FOR WATER AND SOLID IN PULP

	Weight of Pulp	Volume of Pulp	Weight of Dry Solid	Weight of Water	Volume of Water
One ton of pulp, 2,000 lb	1 ton	$\frac{1}{p}$ fluid ton $\frac{32}{p}$ cu.ft.	$\frac{S}{100}$ ton $\frac{1}{R+1}$ ton $\frac{(p-1)k}{100p}$ ton	$\frac{d-p}{p(d-1)}$ ton	$\frac{d-p}{p(d-1)}$ fluid ton $\frac{32(d-p)}{p(d-1)}$ cu.ft.
1 fluid ton of pulp, 32 cu.ft. 240 U. S. gallons 200 Imp. gallons	p tons	1 fluid ton 32 cu.ft.	$\frac{(p-1)k}{100}$ ton	$\frac{d-p}{d-1}$ ton	$\frac{d-p}{d-1}$ fluid ton $\frac{32(d-p)}{d-1}$ cu.ft.
1 cu.ft. pulp 7.5 U. S. gallons 6.25 Imp. gallons	62.5 p lb.	1 cu.ft. 0.03125 fluid ton	0.625(p—1)k lb. $\frac{(p-1)k}{3200}$ ton	$\frac{62.5(d-p)}{d-1}$ lb. $\frac{d-p}{32(d-1)}$ ton	$\frac{d-p}{d-1}$ cu.ft.
1 ton dry solid 2,000 lb	(R+1) tons $\frac{100p}{(p-1)k}$ tons	$\frac{100}{(p-1)k}$ fluid ton $\frac{3200}{(p-1)k}$ cu.ft.	1 ton	R tons $\frac{100}{S}$ — 1 ton $\frac{d-p}{d(p-1)}$ ton	32 R cu.ft. R fluid tons
1 fluid ton water, 32 cu.ft. 240 U. S. gallons 200 Imp. gallons	$\frac{p(d-1)}{d-p}$ ton	$\frac{d-1}{d-p}$ fluid ton	$\frac{1}{R}$ ton $\frac{d(p-1)}{d-p}$ ton $\frac{S}{100-S}$ ton	1 ton	1 fluid ton 32 cu.ft.

One U. S. gallon of pulp = $\frac{(p-1)k}{12}$ pounds of dry solid. One Imperial gallon of pulp = $\frac{(p-1)k}{10}$ pounds of dry solid.

The relation between metric ton (1,000 kg.) and cubic meter (1,000 liters) is the same as between the ton of 2,000 lb. and the fluid ton of 32 cu.ft. One cubic meter of pulp contains 0.01 (p—1)k metric tons of solid.

functions of d and R as in formulas (11) and (14) are easily had by transposition. Formulas in S are had by substituting appropriate expressions given in (13) and (14). Also, since 100 cu.ft. pulp weighs 100 p units and contains S per cent of solid, the volume of solid in this volume of pulp is its weight divided by its density, or $V = \frac{Sp}{d}$, as shown in formula (16). Formula (15) is thus self-evident.

$$(11)\quad d = \frac{p}{1 - R(p-1)} = \frac{Sp}{Sp - 100(p-1)}$$

$$(12)\quad p = \frac{R+1}{R+\frac{1}{d}} = \frac{100}{100 - \frac{S(d-1)}{d}} = \frac{k}{k-S}$$

$$(13)\quad S = \frac{100}{R+1} = \frac{100d(p-1)}{p(d-1)} = \frac{k(p-1)}{p}$$

$$(14)\quad R = \frac{d-p}{d(p-1)} = \frac{1-\frac{p}{d}}{p-1} = \frac{100-S}{S} = \frac{100}{S} - 1 = \frac{100p}{k(p-1)} - 1$$

$$(15)\quad F = Sp = \frac{100p}{R+1} = \frac{100d(p-1)}{d-1} = k(p-1)$$

$$(16)\quad V = \frac{F}{d} = \frac{Sp}{d} = \frac{100(p-1)}{d-1} = (k-100)(p-1)$$

$$(17)\quad \text{Fluid tons of pulp to give one ton dry solid} = \frac{100}{F} = \frac{100}{k(p-1)} = \frac{R+1}{p}$$

For very thin pulps, specific gravity under 1.05, S and F are practically identical, and it may be stated that S or F = k (p — 1). This is an approximation to be used for the overflow of slime settlers, spitzkasten, etc., but its limitation should always be remembered. Table I gives the above relations in a simplified manner and in a form suitable for calculation by slide rule.

Sampling Pulp

The specific gravity of pulp may be determined by several methods. The hydrometer can be used provided the pulp is not extremely thick. However, it is very difficult to keep the coarser material in the pulp from settling, and some of the pulp usually sticks to the bulb of the instrument, consequently the hydrometer usually gives results that are only approximately correct. A very satisfactory method is to use a specific gravity flask* made of tin in the form of a cone (Fig. 1). The bottom diameter is 6.5 in. and the side makes an angle of 60 deg. with the flat bottom. The flask should be calibrated by denting the bottom until it holds just 100cc. A tare weight which just balances the flask when it is filled with distilled water should be provided. When the flask is filled with pulp and weighed, the weights in excess of the tare weight give the decimal part of the specific gravity of the pulp. Thus, extra weights of 345 g. mean that the pulp has a specific gravity of 1.345. In general, there is no advantage to be derived from weighing closer than the nearest 5 g. or to within 0.005 of the specific gravity. A 1000-cc. graduate can be used in the same manner. Still another method is to use a bucket that holds one cubic foot of pulp. A bucket 14 in. in diameter will hold one cubic foot when filled to a depth of 11.25 in. The cubic foot point should be marked by boring a small hole through the bucket and inserting a rivet or bolt. In use, a tare weight is used to balance the empty bucket, and the weight of one cubic foot of pulp in pounds times the factor 0.016 gives the specific gravity of the pulp. A modification of this method is to mark a bucket at a point where it holds exactly 100 pounds of water. The weight of this volume of pulp in pounds gives the specific gravity directly by pointing off as decimal all figures to the right of the initial left hand figure (which is always 1).

FIG. 1. SPECIFIC GRAVITY FLASK

Care must be exercised that the sample taken is a true average of the entire volume of pulp under consideration. A small funnel or a rectangular shaped piece of tin made to slip into the neck of the specific gravity flask will enable the sampler to cut a running stream of pulp in a satisfactory manner. If the sample is to be taken from a bucket or other container, the pulp should be stirred vigorously just before taking the sample to insure that the coarser particles have not settled to the bottom of the bucket.

Density of Solids

The specific gravity of a dry solid, sand or slime is best determined by means of a weighing bottle, whose size depends upon the sensitiveness of the balance used. Twenty-five to 50 cc. is a good size for use on a pulp balance and 200 to 1000 cc. capacity should be used on a balance sensitive to 0.1 g. First fill the bottle to the top, or to a well defined mark near the top, with water and weigh. Then empty the bottle and fill half to two-thirds full of the wet sand or slime. Cover with water and shake well, removing the last traces of air bubbles by suction. Fill to the mark with water and weigh. Finally, dump out the sand or slime, dry it carefully and weigh.

$$(18)\quad \text{Density } d = \frac{\text{Wt. of dry sand}}{\text{Wt. of bottle full of water} + \text{Wt. of dry sand} - \text{Wt. of bottle with sand and water}}$$

If the sand is first dried and weighed, and a definite quantity is taken for the test, the result will be too low unless the sand is boiled in water or soaked for a long time. It is very difficult to thoroughly wet dried sand or slime. Again, wet sand must be well dried before weighing, as any contained moisture lowers the apparent density. If the wet sand contains n per cent of moisture by weight, the apparent density $= \frac{100d}{100 + n(d-1)}$, where d is the true density of the dry material. A quick and closely approximate method for determining the density of a fine concentrate is as follows: Fill a burette to a given mark with pure water at standard temperature, weigh out carefully about 20 g. dry concentrate, and run into the burette by means of a piece of glazed paper, taking care that all goes under water. Note the increased volume due to water displaced by the

concentrate. Then the density of the concentrate is its weight in grams divided by the volume of water displaced in cubic centimeters.

It is often important to know the interstitial space in settled sand or in a filter cake. The maximum volume of voids is obtained when moderately moist material is shoveled or fed by a mechanical distributer into a vat. In a vat of sands having n per cent interstitial space, the speed of percolation will be 100/n times the leaching rate. Thus, if the solution covering a vat of sand drops at the rate of 2 in. per hour, and the interstitial space is 40 per cent, the speed of the solution descending through the sand is $100/40 \times 2 = 5$ in. per hour. Since the depth of the tank or vat is known, the time of draining or the time that a change in the strength of the solution will be apparent in the effluent solution can be closely approximated, provided the material is uniformly distributed in the vat. In settled sands, the interstitial space may range from 40 to 55 per cent.

Let w = grams of material in 100 cc. (including moisture), or lb. per cu.ft. times 1.6.
s = per cent of solids, if material is wet.
d = density of dry solid.
k = 100d/(d — 1), a constant for each material.

For dry material:

(19) Per cent voids or interstitial space $= 100 - \frac{w}{d}$

Thus, for a tailing of 2.65 specific gravity and weighing 80 lb. per cu.ft., the percentage of voids is $100 - \frac{80 \times 1.6}{2.65} = 51.7$ per cent.

For wet material:

(20) Per cent of actual voids or air space $= 100 - w\left(1 - \frac{s}{k}\right)$

(21) Per cent of total space occupied by air and water $= 100 - \frac{ws}{100d}$

(22) Per cent of volume occupied by water $= \frac{w \times \text{per cent moisture}}{100} = \frac{w[100 - s]}{100}$

Thus for partly drained tailing, weighing 95 lb. per cu.ft., with 15 per cent moisture and 85 per cent solids of specific gravity 2.5, the space occupied by air and water is found as follows:

$k = \frac{100 \times 2.5}{2.5 - 1} = 166.7$; $s = 85$ and $w = (95 \times 1.6)$

From (20), $100 - (95 \times 1.6)\left(1 - \frac{85}{166.7}\right) = 25.5$ per cent dry air space.

From (21), $100 - \frac{(95 \times 1.6) \times 85}{100 \times 2.5} = 48.3$ total interstitial space, in per cent of total volume.

The difference of 22.8 per cent is the space occupied by water.

Also from (22), $\frac{(95 \times 1.6)(100 - 85)}{100} = 22.8$ per cent of total space occupied by water.

The capacity of a filter press is most accurately determined by blowing as nearly dry as possible before opening, then selecting several pairs of frames, those of each pair being equidistant from the ends, weighing the entire contents of each frame separately and also determining the moisture in each. Average these figures to get the result per frame and then multiply by the number of frames. A quicker way is to measure the volume of effluent water from the press. This can generally be easily done, as most mills have solution meters on all important pipe lines. Also determine the water ratio, R, of the incoming pulp, and the water ratio, M, of the cake.

A test gave the following results: Water ratio of pulp 4:1; cake contained 40 per cent moisture; total effluent water = 20 tons.

Then R = 4, and $M = \frac{\text{per cent water in cake}}{\text{per cent solids in cake}} = \frac{40}{60} = 0.667$.

(23) Tons solids in press $= \frac{\text{Tons effluent water}}{R - M} = \frac{20}{4 - 0.667} = 6$ tons.

Sluices and Launders

When sluicing wet material from tanks or vats by water or a stream of solution, the calculations are complicated by the fact that water from two sources enters into the mixture.

Let C = per cent dry sand or slime in the material before sluicing
M = water ratio of material before sluicing
= per cent water divided by per cent dry solid
$= \frac{100 - C}{C} = \frac{100}{C} - 1$
R = water ratio of material after sluicing
$= \frac{100 - S}{S}$, where
S = per cent solid in the material after sluicing
E = net sluicing efficiency = tons dry solid moved by 100 tons of added sluicing solution
Q = tons sluicing solution required per ton of dry solid in material sluiced to give a product of S per cent dry solid and R water ratio.

(24) Then $E = \frac{100}{R - M} = \frac{CS}{C - S}$

(25) $Q = R - M = \frac{100}{S} - \frac{100}{C} = \frac{100(C - S)}{CS} = \frac{100}{E}$

(26) Tons water added per gross ton of wet material sluiced $= \frac{QC}{100} = \frac{C(R - M)}{100} = \frac{C}{S} - 1 = \frac{C}{E}$

Thus, if sand in a vat contains 40 per cent moisture, and it is desired to sluice it out so that the resulting pulp will have a water ratio of 3 to 1, we have

$M = \frac{40}{60} = 0.667$; $E = \frac{100}{3 - 0.667} = 42.9$; and

$Q = 3 - 0.667 = 2.33$

In the control of mill operations, it is often necessary to measure the amount of pulp flowing in certain launders. Such measurement is useful for determining the amount of feed going to some machine or the quantity of product coming from the machine.

(27) Tons dry solid per day $= \frac{\text{Pounds dry solid caught} \times 43.2}{\text{Seconds required for catching}}$

(28) Tons dry solid per day $= \left(\frac{2700d}{d - 1}\right) \times \left(\frac{p - 1}{t}\right)$

(29) Tons dry solid per day $= \frac{(27k)(p - 1)}{t}$

where t = time in seconds required to catch one cubic foot of pulp using the entire stream, p is the specific gravity of the pulp, and d is the density of the dry solid, and $k = 100d/(d - 1)$.

Methods of applying the above formulas:

Method No. 1. Turn the whole stream into a suitable bucket or tub, and, when nearly full, switch off stream, noting the exact time of catching by means of a stop watch. Dry the entire catch, weigh and apply formula (27).

Method No. 2. Turn the whole stream into a large tank, switching off after a known considerable interval, say, one minute. Measure the volume and calculate t. In a smaller vessel catch sufficient pulp so its volume can be correctly determined, approximately 1000 cc. or 1 cu.ft. Dry, weigh and calculate the dry pounds of solid per cu.ft. of pulp. Apply the formula:

$$\text{Dry tons per day} = \frac{\text{pounds per cu.ft.} \times 43.2}{t}.$$

Method No. 3. Determine the value of t as in method No. 2. Catch a moderate sized sample of pulp in a bucket and determine net weight. Then dry and weigh the pulp. Calculate S, the percentage by weight of dry solid in the pulp. Then $p = \frac{k}{k - S}$. Apply formula (29).

Method No. 4. Determine t as above. Find the specific gravity of the pulp, p, directly by means of the specific gravity flask. Apply formula (29).

Method No. 5. Single measurement for small flows: In a bucket, marked to hold just one or two cu.ft., catch the pulp, noting exact time. This gives the value of t. Find the weight of the pulp by weighing and deducting the tare of the bucket. p = weight of pulp per cu.ft. times 0.016. Apply formula (29).

Accurate Timing Essential

For accurate results, the time by stop watch for catching samples should never be less than 20 seconds, and a minute or more is to be preferred. Galvanized iron washtubs are convenient for catching small flows and wooden tanks will serve for larger flows. The importance of a sharp and clean cutting of the stream at the time of deflection and when the stream is returned to its usual channel cannot be over-emphasized. The filling of the receptacle takes place all too quickly for the most accurate results and a second's difference between the timing and the actual flow may introduce no small error into the calculations, especially when the report is made in terms of tons of solid per 24 hours. Unless a mill has been designed with launders purposely arranged to facilitate sampling, the ingenuity of the sampling crew will, in many cases, be put to the test to secure a satisfactory sample. It may be necessary to tap a launder beneath a floor or in such a cramped space that, at first, it seems useless to make the attempt. Once a sample has been taken it should be carefully handled until it is ready to be discarded. If any of the pulp is allowed to spill on the floor, the entire sample should be rejected and a new one taken. In case the whole stream cannot be deflected, the sample must be secured by making a cut across the stream as it falls freely through the air. The cutting edge of the sampler must extend through the thickness of the stream and a little beyond to insure a complete cut, and it should move at a uniform rate of speed from one side of the stream to the other. The proper speed to use is dependent upon the volume of pulp that is desired for the sample.

Once a mill has reached the point of steady and continuous operation, it is generally possible greatly to simplify calculations of performance by using certain constants in the formulas[24]. Such quantities as d, k, 27k, etc., change so little that they may safely be considered as constants. Useful curves[23] and charts[21] can be constructed, which show at a glance the relation between density of dry solid, specific gravity of pulp and tons of dry solid per day[25]. Tables showing the contents of dry solid for various sizes of tanks and per foot or inch of depth are valuable time savers.

Formulas for Heavy Solutions

Up to this point all calculations have been made upon the assumption that the specific gravity of the water or solution in the pulp has the value of unity. In some cases the presence of dissolved salts may change the specific gravity of the mill solution so that correct results would not be obtained by using the formulas given above. It is worth noting that a variation in the specific gravity of the solution has a much greater effect than a corresponding variation in the specific gravity of the dry solid. However, such cases may be considered exceptional, and the formulas already stated will usually give satisfactory results and are the ones in common use. Nevertheless, it is well to know their limitations, and formulas in which the specific gravity of the solution is considered as a variable will now be given[5].

Denoting the specific gravity of the solution as D, and using the same notation as in formulas (11) to (17)

(30) $$S = \frac{100(p - D)d}{p(d - D)}$$

(31) $$p = \frac{100D}{100 - S\frac{(d - D)}{d}}$$

(32) $$R = \frac{D(d - p)}{d(p - D)}$$

(33) Cu.ft. of pulp required to make 1 ton dry slime

$$= \frac{32\left(100 - S\frac{(d - D)}{d}\right)}{DS}$$

(34) Weight of dry slime in pounds in 1 cu.ft. of pulp

$$= \frac{62.5d(p - D)}{d - D}$$

(35) Volume of pulp in cu.ft. containing 1 ton dry slime

$$= \frac{32(d - D)}{d(p - D)}$$

(36) Percentage by weight of solution in pulp =

$$100 - S = \frac{100D(d - p)}{p(d - D)}$$

(37) Volume in cu.ft. of 1 ton of pulp =

$$\frac{100 - S\frac{d - D}{d}}{3.125D} = \frac{32}{p}$$

(38) Weight in pounds of 1 cu.ft. of pulp =

$$\frac{6250D}{100 - S\frac{(d - D)}{d}} = 62.5p$$

Variations in temperature cause a change in the volume of wet pulp. The effect of change of temperature is discussed by Clevenger, Young and Turner[20]. This article also contains extensive tables and charts dealing with the specific gravity of slime pulps.

Economic vs. Metallurgical Efficiency

In every mill there are two kinds of efficiency that require consideration. Metallurgical efficiency is concerned with the highest extraction that it is possible for individual machines and the whole plant to make. Economic efficiency is interested only in the greatest profit the plant will yield. If the two are attained at the same time, operating conditions may be said to be ideal, but this is seldom if ever the case. By crowding ore through it a mill can be made to produce a larger tonnage of concentrate than when operating under normal conditions. Though the concentrate is of lower grade, the net result is greater returns from the metals sold and generally greater profits. The metallurgical efficiency or per cent extraction may be much lower than before. Nevertheless, the increased profit more than offsets the greater loss in the tailing and the economic efficiency of the plant is increased[20]. Economic efficiency is calculated from the cost of labor, the cost of supplies and the selling price of metals. It, therefore, contains enough variables to constitute a live question to any mill management.

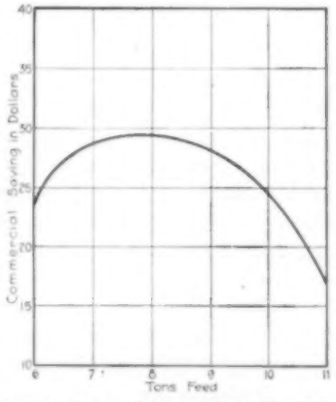

FIG. 2. ECONOMIC EFFICIENCY OF VANNER

As an illustration of the application of the principle of greatest economic efficiency the saving made by vanners treating copper ore will be considered. A chart like Fig. 2 can be made in which the value of the total metal saved per day by a vanner, less the cost of operation, is plotted against the tons of feed coming to the vanner. Such a chart shows at a glance the vanner makes the greatest saving when handling about 7.8 tons of feed per day. Of course, the relation of the product of each concentrating machine to the whole milling process must be remembered. A vanner making a fairly clean concentrate, going to market without further treatment, would not be operated in the same way if it was desired to produce a dirty concentrate which would be cleaned in a flotation machine.

Hand Sorting

The problem whether hand sorting of ore before milling will be profitable or not cannot be decided without making a close study of conditions. Sorting may have for its object the rejecting of material so low in grade that it cannot be milled at a profit, or it may be employed to keep hard and tough waste out of the mill and thereby reduce the cost of fine grinding[20]. Items such as the grade of the rejected material, the cost of sorting, milling and smelting charges and the current prices of metals all enter into the calculations that must be made. These have been expressed in formulas as follows.[21]

Let C = grade of ore before sorting
A = grade of ore after sorting
B = grade of rejected material
N = percentage of the unsorted ore that is rejected
M = milling or smelting charges, including loss in tailing
V = current price of metal exploited
P = cost of sorting per ton of sorted ore.

Then, number of tons of unsorted ore required to produce 1 ton of sorted ore $= \frac{1}{1 - 0.01N}$

Tons of waste from the above unsorted ore $= \frac{0.01N}{1 - 0.01N}$

If there was no sorting the apparent yield from the waste of grade C $= \frac{0.01NCV}{1 - 0.01N} - \frac{0.01NM}{1 - 0.01N}$

This amount is lost by rejecting the waste, and this loss must be overbalanced by the rise in value of the sorted material. This rise is (A — C) V — P. Hence the saving from sorting =

$$[(A - C)V - P] - \left(\frac{0.01CVN}{1 - 0.01N} - \frac{0.01NM}{1 - 0.01N}\right)$$

Now since the values existing in the sorted ore plus that in the waste equals that in the ore before sorting, $A + \left(\frac{1}{1 - 0.01N} - 1\right) B = \frac{C}{1 - 0.01N}$, whence

$$A(1 - 0.01N) + 0.01NB = C \text{ and}$$

$A - C = 0.01N\ (A - B)$, in which case the saving in sorting =

$$\frac{0.01(M - VB)N}{1 - 0.01N} - P.$$

This formula has been worked out on the assumption that M remains constant despite variation in tonnage, and is true for large plants. For small mills the reduction in tonnage resulting from sorting the ore would increase the cost of milling because the fixed charges constitute a relatively high percentage of the total milling cost. The value of M would then have to be changed according to conditions.

Use of Microscope

For some years the microscope has been the chief means of determining the exact nature of different kinds of ores and rocks. Thin sections, when viewed in polarized light, not only show the mineralogical composition of the ores or rocks but also the order of formation of the different crystals and their relations to each other. Many valuable geological deductions have been made from such information. Strange to say, the value of the application of the microscope to ore dressing has not, until recently, been generally recognized. Even in unskilled hands much can be learned by means of the instrument[22]. The measurement of the size of mineral grains, the size of aperture and diameter of the wire in screens, the degree to which crushing must be carried in order to free the grains of valuable minerals in an ore, the amount and condition of the middling product made by any machine and the efficiency of sulphide filming for flotation treatment are easy possibilities for the uninitiated[23]. With a little practice minerals of similar appearance can be differentiated, using the Becke

method of finding the refractive index of grains in mineral powders. The examination of polished opaque sections in reflected light may show the presence in the ore of unsuspected minerals[40]. Through the study of the shape of grains after an ore has been crushed the behavior of the ore under the usual conditions of concentration can be quite accurately predicted. A very complete mineralogical analysis of the crushed ore or concentrate produced can be made by the use of the microscope combined with a separation of the grains in heavy solutions of different specific gravities[40].

This list does not exhaust the possibilities of the microscope as applied to ore dressing. It is safe to say at any plant the cost of the apparatus and the value of the time spent in investigation will be well repaid by the increased efficiency of operation that will result from such a study. The advantages of this method of mill control cannot be too strongly urged.

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Navy Department to Sell Explosives Plant

The Navy Department has begun the sale of surplus material in its possession consisting of an explosives plant at Mt. Union, Pa., lumber, chemicals, machinery, etc. Sealed proposals have been asked for on a small quantity of condemned stores and the balance will be placed on sale as fast as it is released. The disposition of the material is being made through the bureau of supplies and accounts, Navy Department, of which Rear Admiral McGowan is chief, under the direction of Lieut. C. G. Peterson.

The property which will be offered for sale by the Navy Department is small compared with the surplus material of the War Department. One of the largest items is the explosives plant at Mt. Union, which is valued at $1,500,000. Only the TNT unit will be placed on sale, the powder section having been disposed of to the Aetna Powder Co. The Navy Department announces that the purchaser will have the option of placing the plant in operation or of scrapping it.

A large quantity of copper purchased by the Department at high prices will not be sold, but will be stored for the future use of the Navy.

Storage Tanks Made of Reinforced Concrete*

Details of a Large Installation of Concrete Tanks—Preliminary Tests on Permeability for Water and Ammoniacal Liquor—Drawings, Construction, and Costs

BY F. W. FRERICHS

ABOUT a year ago it became necessary to construct large storage tanks for ammoniacal liquors. Usually such tanks are made of steel, but on account of the war steel plates were not obtainable and concrete was the next best material which was available for the construction. By preliminary experiments it was proved that good concrete was not materially affected by crude ammoniacal liquor, and in order to ascertain the permeability of concrete walls by water and aqua ammonia four small experimental tanks were constructed and subjected to systematic tests.

The accompanying sketch (Fig. 1) illustrates the construction of the tanks, one of which was made from cement concrete consisting of one part cement, two parts sand, and four parts gravel. This tank was designated by the letter "A." The three other tanks were made from the same concrete mixture with the sole difference that in tank "B" 2 per cent hydrated lime was added to the cement before mixing, while tanks "C" and "D" contained 2 per cent each of two other waterproofing materials (stearates) of the market.

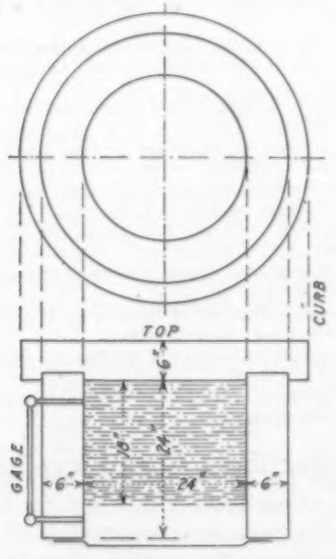

FIG. 1. SKETCH SHOWING CONSTRUCTION OF THE TANKS

Each tank carried a gage glass on the side in which the level of the liquid in the tank could be observed. A sheet-iron circular cover was cemented to the top to prevent loss by evaporation. During the test period the tanks were standing in the open air exposed to the hot summer sun and the outside surfaces appeared dry. The inside area of each tank was 15.70 sq.ft.; the outside area was 35.74 sq.ft.

*Read before the Chicago meeting of the American Institute of Chemical Engineers, Jan. 17, 1919.

After ten days' drying the tanks were subjected to the following tests with a view of ascertaining the permeability of concrete by water and ammoniacal liquor:

SERIES I.—PERMEABILITY FOR WATER

All four tanks were filled with water 18 in. high to within 6 in. from top, and the iron covers luted on tight with cement. Readings of water in gages were taken every day at 3 p.m. and the drop in the water level was recorded as read in inches.

	I		II				III				IV			
	Temp.,		Drop in Surface				Evaporation				Evaporation			
1917	Max.	Min.	A	B	C	D	A	B	C	D	A	B	C	D
	Deg. F.	Deg. F.	In.	In.	In.	In.	Cu.In.	Cu.In.	Cu.In.	Cu.In.	Cu.In. per Sq.Ft. Outside Area.			
July 13	96	69	0.00	0.00	0.00	0.00								
14	81	67	0.63	0.38	0.13	0.75	285	172	59	339	11.6	6.9	2.4	13.5
15	84	67	0.75	0.38	0.19	0.94	339	172	76	425	13.5	6.9	3.0	17.0
16	83	68	1.00	0.38	0.19	1.19	452	172	76	538	18.0	6.9	3.0	21.5
17	82	64	1.19	0.50	0.38	1.38	538	226	172	624	21.5	9.0	6.9	25.0
18	83	68	1.38	0.50	0.38	1.50	624	226	172	678	25.0	9.0	6.9	27.1
19	86	69	1.56	0.56	0.38	1.63	705	253	172	737	28.0	10.1	6.9	29.5
20	90	68	1.69	0.63	0.38	1.75	764	285	172	792	30.5	11.4	6.9	31.7
21	90	69	1.81	0.69	0.44	1.88	818	311	199	850	32.7	12.4	8.0	34.0
22	93	73	1.94	0.78	0.47	2.00	877	352	212	904	35.0	14.1	8.5	36.2
23	87	67	2.06	0.88	0.50	2.13	931	397	226	963	37.2	15.9	9.0	38.5

Column I. Temp. max. and min. from Weather Bureau.
Column II. Drop of level in gage in 1/100 inches.
Column III. Evaporation in cu.in.
Column IV. Evaporation in cu.in. per sq.ft. outside area of 25 sq.ft. exposed to atmosphere.

Counting the decrease for the first day for saturation of the concrete, then the average evaporation per day per sq.ft. outside area of 25 sq.ft. has been for A 2.8 cu.in.; B 1.0 cu.in.; C 0.7 cu.in.; D 2.8 cu.in.

SERIES II.—PERMEABILITY FOR 18-IN. AQUA AMMONIA

All four tanks were filled with aqua ammonia 18 in. high to within 6 in. from top, and the iron covers luted on tight with cement. Readings of level in gage were taken every day at 3 p.m. and the drop of level was recorded in 1/100 in.

	I		II				III				IV			
	Temp.,		Drop in Surface				Evaporation				Evaporation			
1917	Max.	Min.	A	B	C	D	A	B	C	D	A	B	C	D
	Deg. F.	Deg. F.	In.	In	In.	In.	Cu.In.	Cu.In.	Cu.In.	Cu.In.	Cu.In. per Sq.Ft. Outside Area.			
Aug. 6	85	68	0.00	0.00	0.00	0.00								
8	85	71	0.31	0.31	0.13	0.25	140	140	59	113	5.6	5.6	2.4	4.5
9	78	64	0.56	0.44	0.25	0.38	253	199	113	172	10.1	8.0	4.5	6.9
10	76	60	0.94	0.50	0.31	0.44	425	226	140	199	17.0	9.0	5.6	8.0
11	80	63	1.25	0.56	0.38	0.50	565	253	172	226	22.6	10.1	6.9	9.0
12	79	65	1.38	0.63	0.44	0.56	624	285	199	253	25.0	11.4	8.0	10.1
13	84	66	1.50	0.69	0.50	0.61	678	312	226	276	27.1	12.5	9.0	11.0
14	83	68	1.75	0.71	0.56	0.63	791	321	253	285	31.6	12.8	10.1	11.4
15	80	69	1.81	0.73	0.63	0.67	818	330	285	303	32.7	13.2	11.4	12.1
16	86	71	1.94	0.75	0.69	0.71	877	339	312	321	35.1	13.6	12.5	12.8
17	91	72	2.06	0.81	0.75	0.75	931	366	339	339	37.2	14.6	13.7	13.7

Columns I—IV designate the same as in Series I.

The aqua ammonia in the tanks did not perceptibly decrease in strength in the ten days' test. The tanks were exposed to the hot sun.

Counting the decrease of the first two days for saturation of the concrete, then the average evaporation per day per sq.ft. outside area exposed to the atmosphere (25 sq.ft.) was for A 3.5 cu.in.; B 1.0 cu.in.; C 1.25 cu.in.; D 1.02 cu.in.

After these tests were made the tanks were dried out and painted on the inside with three coats of raw gas tar. The tar used for the first coat was thinned down with about 10 per cent turpentine, which caused the tar to penetrate about one-eighth of an inch into the concrete. After one week's drying the tanks were tested again with ammoniacal liquor and during several months there was no appreciable loss of their contents.

Three Storage Tanks

Encouraged by these results three large storage tanks were built by plans which were prepared by Messrs. Brenneke & Fay, civil engineers of St. Louis, who describe them as follows:

Three tanks were built in a concrete pit 47 ft. 2 in. wide, 130 ft. long and 30 ft. deep. The excavation for the pit was made in the slope of the river bank partly in earth and partly in solid rock. The bottom, side and end walls rest on solid rock. The walls of the pit are designed as vertical reinforced concrete slabs, their bottom edge being heeled into a trench cut in the rock and the top edge reinforced with a flange acting as a horizontal girder. The tops of the walls are tied across to the opposite walls at intervals by a system of longitudinal and transverse beams which are reinforced to act in either tension or compression, these beams being supported at their intersections by columns from the bottom of the pit. The walls of the pit are so reinforced as to resist hydrostatic pressure in either direction. The north and east walls, which are the upstream and river walls, are also designed to resist the impact of running ice during a high water stage.

After the side walls were built the bottom of the pit was covered with concrete to make it tight, and is reinforced with steel in both directions as a precaution against any upward pressure that might occur during high water on account of fissures or cavities in the rock underneath. In the concrete bottom, sumps are provided to collect rainwater, seepage or leakage from the tanks. Circular chases were also left in the concrete bottom in which to heel the side walls of the tanks in order to get a tight joint between the walls of the tanks and the bottom. The longitudinal and cross beams between the walls at the top of the pit are also designed to support a concrete floor should a building be constructed over the pit in the future. All concrete work in the pit is composed of one part red ring portland cement, two parts sand, and four parts washed and screened Meramec gravel. The accompanying plans (Fig. 2) show the general design, dimensions and details, as well as the steel reinforcement of both the pit and tanks.

The three tanks are 35 ft. inside diameter, and 26 ft. deep. The walls are 7 in. thick, and the tops are covered with a concrete roof 6 in. thick. Manholes are provided in the roof of each tank and are constructed with a double curb of concrete 6 in. high around the

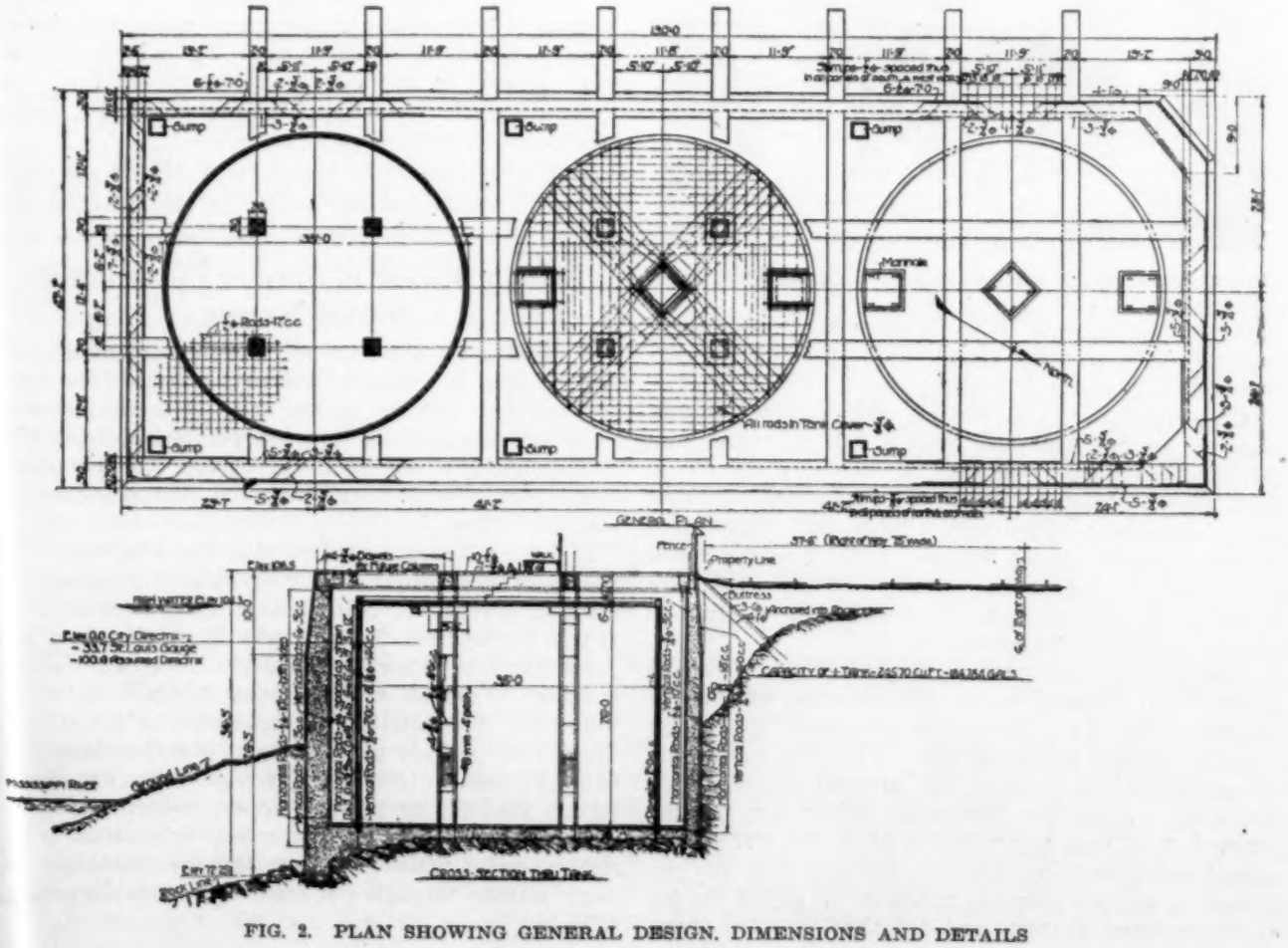

FIG. 2. PLAN SHOWING GENERAL DESIGN, DIMENSIONS AND DETAILS

openings. The manholes have metal covers in the form of an inverted pan, the edges of which rest in the groove between the curbs, and the groove is filled with water to form a seal to prevent the escape of gases from the tank.

The roofs of the tanks are also constructed with a curb about 6 in. high around the edge so that the entire roof can be covered with water as an additional seal against the escape of gases through the concrete.

Plain Concrete Tanks Watertight

As the tanks are to contain ammonia liquor it is essential that they should be tight. Preliminary to their construction several small experimental tanks about 3 ft. in diameter were built with and without waterproofing compounds mixed with the concrete. The plain concrete tanks apparently were as watertight as those in which compounds were used. From the information obtained from these experimental tanks, and from various other sources, it was concluded that waterproof tanks could be built of plain concrete. It is essential that all joints in the walls be eliminated and the concrete be mixed dry, that is, of a consistency of a stiff mortar and then thoroughly rammed. In order to eliminate all joints it was necessary to arrange to concrete continuously day and night from the time the walls were started until they were finished. The vertical reinforcing rods were first secured in position,

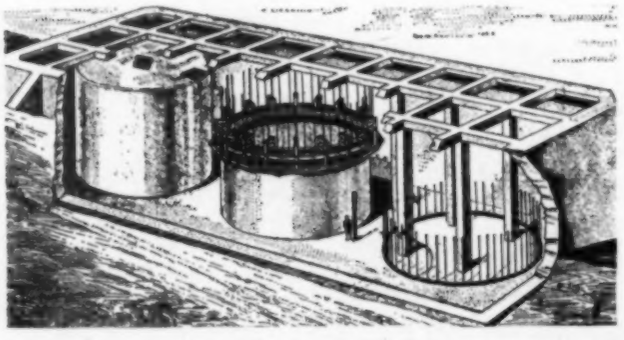

FIG. 3. PERSPECTIVE DRAWING OF THE THREE TANKS

sixteen of which were 1¼-in. diameter plain rods located equidistant around the circle, the balance of the rods being ¾-in. diameter deformed rods.

On each of the 1¼-in. vertical plain rods was placed a metal sleeve constructed with a pair of metal jaws so arranged as to grip the rod wherever the sleeve was placed. The outside of the sleeve was threaded full length and provided with a large nut. From these sleeves were suspended wooden yokes having a metal bearing on the nuts on the sleeves. To the yokes were attached the sliding forms for the tank wall and also the working platform for the men.

The general construction of the yokes, forms and platform is indicated on the accompanying perspective drawing (Fig. 3). The forms were about 5 ft. high made in sections bolted together. The faces were made of quarter-sawed tongued and grooved material laid vertically. After the horizontal reinforcing for the lower 5 ft. of tank was wired in place, the forms were placed and concreting started. The concrete was delivered by a chute from the mixer at the top of the pit to the working platform and deposited into the forms in thin layers and thoroughly tamped. As soon as the concrete reached the top of the forms, the movement of the forms was started by turning up the nuts on the threaded sleeves. This work was carried on continuously day and night, no stopping in the work of concreting or movement of forms being allowed from the time of starting until the wall was finished.

The placing of the longitudinal reinforcing steel was carried on at the same time. As soon as a nut reached the top of its sleeve the load on it was relieved and the nut backed down to the bottom and the sleeve slid up the rod and secured to a new position, and the process of jacking continued. The movement of the forms was made uniform by taking an equal number of turns on each nut in rotation. The rate of movement varied from about 8 in. per hour during the cool hours before sunrise to about 14 in. per hour during the heat of the day, as the time of setting of the concrete was affected by the temperature of both materials and atmosphere. After the top of the wall was reached and the concrete set, the forms were disconnected and removed and used again on the next tank. The concrete roofs were put on at a later date after the walls were thoroughly set.

The concrete in the tank walls is composed of one part red ring portland cement, two parts sand and three parts washed and screened Meramec gravel.

After the concrete work was completed and the tanks dried out the bottom, sides and roof on the interior were coated with three coats of tar applied with a brush as an additional precaution against leakage of liquid gas.

The tanks were then tested by filling with water. In the walls of the first tank built there was some leakage through slight lifting cracks which was due to the slow movement of the forms. These lifting cracks were avoided by more rapid movement of forms on the balance of the work. The leaks gradually healed up and have practically disappeared.

The capacity of each tank is about 185,000 gal., and cost approximately $10,000 exclusive of the tank pit.

Plan to Dispose of Surplus Government-Owned Nitrate

A meeting for the purpose of taking up the disposition of surplus stocks of sodium nitrate in this country was held recently in the office of the Director of Sales and was attended by a representative of the War Trade Board, a representative of the War Industries Board, the Nitrate Committee, and representatives of the Sales Office.

It developed at this meeting that the Government has a surplus of approximately 226,000 tons of sodium nitrate in the United States and 120,000 tons in Chile. It was decided that the importers should dispose of the surplus in this country and that the Government should endeavor to dispose of the surplus in Chile to foreign interests. A committee was appointed by the Nitrate Committee to draw up an offer to the Government to buy the surplus nitrate, the Government to allow them a certain fixed amount per ton to cover cost of selling.

The operation outlined is simply a continuation of the method under which the consumers have obtained sodium nitrate through the importers since November, 1917.

Economics of the Zinc Industry: A Prophetic Discussion

An Expansion of the Zinc Industry Is Not to Be Obtained by Advertising and Promoting New Uses Alone—In Addition Metallurgical Operations Must Be Perfected and Lower Costs Obtained

By PARKER C. CHOATE

WITH the close of the world war the zinc industry finds itself in a condition demanding serious consideration, with more radical reconstruction in prospect than in almost any other large industry.

Capacity for overproduction exists equal to the extent of the entire pre-war market. The present price of spelter is hardly adequate to meet expenses, even crediting the value of the acid by-product. The price of sulphuric acid will drop, since its production has been greatly stimulated by the war and the consumption has suddenly been heavily curtailed. The labor charges are exorbitant and at best are a large factor in the existing methods of spelter manufacture. The fuel (coal) has increased abnormally in price due to increased labor and freight. Freight tariffs have increased so much that the industrial economic balance is seriously affected, since the zinc smelter must not only meet long freight hauls on ore but a distant distribution of acid and spelter.

Cost to Remain High

Thus the cost of making spelter, of raw material (ore, clay, coal), of labor and freight will probably remain high for a long period, while the selling prices of zinc and acid appear to be on the decline owing to overproduction. To comply with nature's law of demand and supply the best course seems to be to increase spelter consumption and at the same time to decrease the cost of production, since a decreased selling price is the surest means of increasing sales. The American Zinc Institute has already been formed for the purpose of regulating and finding new markets for the metal at home and abroad. This united effort is the first instance of co-operation within the zinc industry, and is very creditable, but so far it has appeared to overlook the real essence of its purpose—largely increased sales—because it is not proposing any radical steps to decrease present manufacturing costs. To increase a market by finding new uses for a commodity by advertising is a favorite method, but it tends to increase the cost of production by the added costs of the advertising propaganda, while the increase of a market by a decreased offering price of the product is automatic. It would therefore seem desirable to discuss the problem of how to produce spelter more cheaply, as the problem of increased sales can safely be left to the advertising agencies now available. However, both methods are very desirable in this instance, since zinc can undoubtedly be advantageously adapted to many new uses.

The best economic weapon with which to meet a bad business situation is not employed or discussed because to decrease the cost of production involves technology and mental development seldom present on the board of directors.

Centers of Present Spelter Production

The sheet-zinc fields lie in the Middle West and have furnished the main ore supply in the past because of the quality of the ore. These fields still play a major but declining rôle because the vein deposits, chiefly of the Northwest, yield the zinc unit at a cheaper mining cost when it is shared by other metals contained in the ore. Fortunately for the older practice, the metallurgy involved in handling the large deposits of cheap vein zinc has been more difficult and so far neglected by the non-technical minds in control of the spelter trade.

When the zinc industry started in America it was natural to locate the manufacturing plant near a bed of coal, because it required several tons of coal for each ton of zinc ore reduced. Clay beds also played a part in the location, as the zinc retort was a prominent item of operating expense. Thus the industry became centered in the Middle West on coal beds and utilized the best-quality zinc ore from the nearest sheet ground. Gradually the fuel consumption has been reduced and is now about one ton of coal for one of ore; a poorer and cheaper quality of zinc ore is also handled and sulphuric acid manufacture installed in order to mitigate the SO_2-gas nuisance caused by the necessary desulphurization.

Future Importance of Vein Ores

The profits on acid and metal-carrying residues have decreased the cost of producing spelter and therefore complicate the economics, but it is unquestionable that the conditions as just outlined and which have created the old zinc industry are now passing.

It is common knowledge that the Northwest and in fact all the Rocky Mountain region contain immense quantities of vein zinc ores of complex character but which are not now carried to market to any extent. The contained zinc has been a curse to the blast-furnace operator smelting for other metals, who consequently penalized the shipper. However, concentration followed by selective flotation is rapidly changing this situation, so that increasingly large quantities of zinc mineral separated from complex vein ores are now being sold to zinc smelters.

The freight tariffs on the long haul from Western mines to the distilling plants in the Central states has been a serious and increasing item of expense, and the inevitable issue will be that the zinc concentrates will be reduced to spelter at or near the point of origin. Ample coal and proper clays do not exist there, nor can sulphuric acid be produced on account of the dis-

tance to market. Fortunately, however, water power does exist as a commodity now undeveloped and valueless; but developed it can compete with coal as a heating agent. Research is also perfecting metallurgical processes to use this hydro-electric power to reduce the heavy labor bill during distillation, to avoid the excessive use of clay and coal and to save more directly a larger proportion of by-product metals.

Leach-electrolysis of complex zinc ores is already established and controls the pure zinc market, but is not a serious competitor of ordinary metal. Electric zinc smelting is probably coming, but presents difficulties in the condensation of the metallic vapor. Electric retorting will probably be the most serious competitor of the present gas retorting, as it eliminates coal, clay and excessive labor bills, and can be installed in small units at any mine having water power. This process will use the lime-briquet reduction process, thus avoiding roasting and acid problems, and by saving the associated lead and silver in the act of distillation without the cost of residue smelting will produce spelter at a materially lower cost than is at present possible in the gas-fired or coal-fired retort.

The coming cheap electrical manufacture of spelter at the prolific vein mines using the new processes of technology presents the strongest and most immediate incentive for the distiller to reduce his now excessive cost of manufacture and to improve the metal extractions. It will produce a market for the miner operating a complex zinc ore property not now profitable; and their number is legion. The gas-retort operator must meet this competitor or disappear.

Improved Gas Retorting

I have already discussed the principles which appear to underlie any radical reduction of the cost of retort spelter in CHEMICAL & METALLURGICAL ENGINEERING, July 1, 1918 (Vol. 19, p. 20), under the title "Research Preparedness in the Zinc Industry." Briefly, the scheme involves costless fuel, lime-briquetting and continuous retorts—admittedly radical changes scrapping the present zinc plants except the organization, general metallurgical utilities and buildings.

Located on the lignite and bituminous fields of the Middle West, the zinc industry has at hand an immense latent gas supply. To make other than a low-grade producer gas will yield a carbonaceous residue, and as the coals are not free coking, the sale of the pulverized residue as such is out of the question. Hard briquetted with its own tars, however, it is a better domestic fuel than coke, and the public will pay a price for such briquets that will pay all mining and treatment costs. Thus an excess retort gas of good calorific power can be obtained as a by-product at no cost to be used in zinc distillation, while the original carbon residue is the best zinc-retort carbon mix obtainable.

Due to the character of the flotation slimes that constitute an increasing proportion of the distiller's ore-supply the act of desulphurization is rendered continually more difficult. Returns from sulphuric acid bolster up the roasting department, but its profitable manufacture is becoming questionable, even though it is a hygienic necessity. The logical solution is the adoption of the lime-reduction process, retorting the briquets of raw ore, a process which has demonstrated its ability to decrease largely the wear and tear on retorts, to increase materially the metal extraction, to conserve about 33 per cent in time of distillation with a corresponding saving in fuel and labor and to be about the only good way to handle the fine flotation slimes.

The continuous vertical zinc retort, with center condenser of large diameter, preheating the charge in the top section, conserving waste heat by preheating the combustion air and gas in the bottom or discharge section, will in the first place greatly reduce the labor bills, but will also conserve heat units beyond the best systems now in use. A form of vertical retort is reported in use in Germany, but America will produce an advanced and durable type using the non-slagging lime briquet.

The technical mind realizes that these economies in gas-fired distillation are practical and must be embraced if the present industry is to be protected. They will cheapen the cost of manufacture and enable the use of the cheapest zinc-unit irrespective of quality.

Economic Summary

Gas-retort practice can conserve one-half or more of its labor bills by adopting the large continuous vertical retort. Fuel gas and retort mix can be obtained at no cost (perhaps at a minus cost, or profit) by entering the lignite retorting business and supplying a large consuming public with suitable domestic coal briquets.

Further conservation in fuel gas, carbon mix and retort wear and tear is obtainable by using the lime-reduction process, at the same time using cheaper complex ores and giving better metal extractions.

In this manner, it is probably practicable to distill a ton of zinc ore with less than one-third ton of coal or its equivalent gas. While it is undesirable to enter into definite figures as to the cents per pound saved by this or that departure from the existing crude practice, it seems obvious that more than 50 per cent of the present cost of spelter can be conserved while utilizing a cheaper zinc unit than the usual concentrate from the Missouri-Kansas-Oklahoma fields.

The present zinc industry must take such steps or practically be driven out of business by more advanced operation. An increased market for spelter cannot be of aid if the present manufacturing cost is to remain.

United Economic Research

While the American Zinc Institute is preparing a market by united effort, it is advisable to unite in large scale research with a view of enabling the present industry to maintain itself, to serve the public with better technical efficiency and to aid in the larger distribution of zinc, by offering the metal at a lower price.

The usual research of individual corporations is quite inadequate in finance or scope to meet such an issue as now presents itself, and the cost of erecting and operating a commercial unit is larger than most zinc companies care to assume. No doubt inventions will be involved and compensation should be paid to the designer or creator. Under united experimental action the entire cost of the tests can be assumed by the agents who perfect the technical advance, the so-called cost of research thus becoming a prepayment on account of the royalties that would later accrue.

While it may require a quarter of a million dollars to practically develop the obvious advances, such a cost will be small as compared to the total which will be incurred by the individual efforts of each corporation experimenting with this and that process or device, or of paying large royalties to some exploiting corporation, which, like Minerals Separation, obtains control of essential patents.

The outlined research is known to be practical, and all that is needed is a balanced assembly to produce the desired result, so that the operating and engineering staff of the contributing zinc corporations can copy and adapt it to suit their several needs. The writer two years ago pointed out that these improvements in the zinc industry consisted of a chain of acts, radical, but connected. To test or adapt one of the proposals will lead to another, so that only a complete installation will yield the desired result.

The subject is submitted for thought and discussion.

Essex, Mass.

Corrosion of Brass in Sea Water

By Paul T. Bruhl

THE corrosion of brass has long been investigated, notably by a committee appointed by the Institute of Metals (London), and experiments have been conducted not only to throw light on the various factors governing the rate of corrosion but also to suggest some other alloy as a substitute for brass if sufficiently effective protective measures cannot be found.

Brass may be said to corrode in two ways; in the first the action is merely mechanical and the metal is abraded; in the second and more dangerous way it is either attacked uniformly over its entire surface or corrosion is strongly localized and we have the phenomena of dezincification and pitting. As the strength of a chain is that of its weakest link, so that of a condenser tube depends upon the length of time which suffices for the development of the first perforation.

In the investigation of the effect of strain it was found that the method of manufacture does not permit of any difference in solution pressure greater than 0.0002 volt. This factor contributing to the rate of corrosion is therefore not a serious one; the anodic areas merely act as loci at which corrosion tends to start and from which it spreads over the whole surface.

The bearing on the subject of annealing—with respect both to time and temperature—has been shown to be small, though annealing by increasing the electromotive force increases the liability to attack. It must always be remembered, however, that corrosion is a complex problem and the reactions it involves are difficult to foretell; so that observations made at the beginning may not hold good at the end of an experiment.

Rolling of the metal has an influence inasmuch as it increases the tendency to corrode by imparting to the metal an added energy, though the solution pressure is diminished by the closer agglomeration of the molecules.

Bilge water and organic oils are harmful, the former owing to the formation of corrosive sulphur compounds, the latter because of the decomposition by steam into products containing free acid.

Stray currents of electricity undoubtedly exert a pernicious effect by causing more rapid removal from the solution of the charged ions. Mr. Milton in discussing this point said, "If, for instance, there is a leakage from the positive cable in such a position that part of it proceeds to the sea (earths) through the water flowing through the condenser tubes, which are, of course, clean metal, instead of through the hull of the vessel, which is kept painted in order to prevent any actual contact between the iron and the sea water, some electrolytic action must take place in the tubes themselves."

I studied the influence of various corrosion products on the rate of corrosion by arranging them in the electrochemical scale and by determining their specific resistances.

The following results, which are approximate, were obtained:

1. Brass.
2. Zinc oxide.
3. The oxychloride.
4. Iron oxide.
5. Cuprous oxide.
6. Cupric oxide.
7. Iron hydrate.
8. Basic zinc carbonate.
9. Coke.
10. Basic copper carbonate.
11. Tin oxide.

The next table gives the order of resistance per cubic centimeter in ohms in the moist state.

1. Coke, less than 1000.
2. Cuprous oxide, less than 1500.
3. Iron oxide, less than 2800.
4. Basic zinc carbonate, less than 4000.
5. Basic copper carbonate, less than 6500.
6. Zinc oxide, less than 7000.
7. The oxychloride, less than 7500.
8. Cupric oxide, less than 10,000.

We see from the tables that the rate of corrosion must be to some extent increased by the mutual interaction between the products of corrosion and by the formation of voltaic couples with the metal itself.

The main consideration in any research on the corrosion problem ought to be the determination of the circumstances which give rise to pitting. Three factors govern the positions of the serious pits; mechanical defects, the presence of certain deposits which act as cathodic centers, and dezincification, that is to say, the preferential solution of the zinc. A spill must be a source of danger (though some do not hold it to be so) as the metal wall where it occurs is thinner and hence corrosion has not so far to proceed to cause a perforation. The deposits which are generally conceded to be injurious are the green oxychloride (which promotes dezincification), carbon and ferric hydrate.

A study of the effect of physical constitution on corrosion has been made. For instance, Muntz metal, which contains 60 per cent copper and 40 per cent zinc, is built up of the alpha and beta phases and the voltaic action between the two accelerates the rate of corrosion, so that at first, before secondary reactions set in, Muntz metal corrodes faster than 70/30 brass which consists of the alpha phase only.

Control of the condenser temperature through the provision of an adequate area of condensing surface, the use of electrochemical protection, the substitution for brass of other metals such as phosphor-bronze, monel metal, alloys of copper and aluminium, and brass with 2 per cent lead, have all been suggested as aids to the partial prevention of corrosion.

Other interesting observations that have been made are that up to a certain point dilution or aëration of the sea water, and in general a rise in temperature or an increase in the amount of CO_2 present, promote the corrosion of brass.

Laboratory Electro-Deposition Plant

By Carle R. Hayward

ONE of the required operations in the metallurgical laboratory of the Massachusetts Institute of Technology is a study of the electrolytic refining of copper. For this purpose a series of five tar-lined vats were used for many years, but part of the value of the operation was lost because the students could not see what was taking place in the vats.

When equipping the new laboratory in Cambridge the writer designed a set of tanks with glass sides which

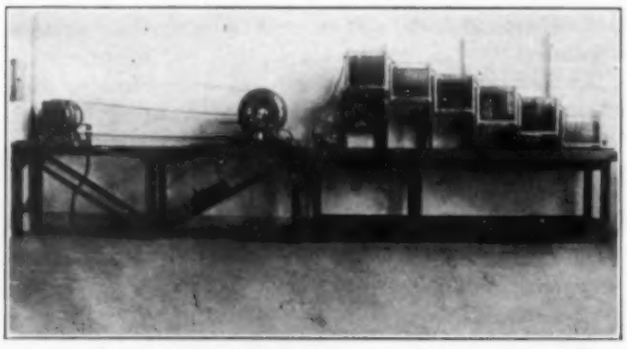

FIG. 1. LABORATORY APPARATUS FOR THE ELECTROLYTIC REFINING OF COPPER

have given excellent satisfaction. A description of the plant will doubtless prove of general interest.

A photograph of the apparatus is shown in Fig. 1 and gives a good idea of its arrangement. A 2-hp. motor is seen at the extreme left belted to a small dynamo which furnishes low voltage current for the process. There are five vats arranged in cascade. Each vat contains four anodes and five cathodes arranged in multiple. The vats are fifteen inches long, seven inches wide and twelve inches deep on the inside. The surface of each electrode submerged in the electrolyte is six inches square.

A vertical section of one of the vats is shown in Fig. 2 and a composite plan and horizontal section is shown in Fig. 3. Both these sketches are to some extent self-explanatory.

It will be noted in Figs. 2 and 3 that the ends of the vats are of slate grooved to receive the slate bottom and the glass sides. The parts are cemented together with litharge and glycerine and held firmly in place by steel tie rods, of which there are two on each side. Each vat has a lead overflow spout on one end and a lead spout in one corner of the bottom for cleaning out the anode mud. The bottom spout is kept closed by a rubber stopper.

Copper rods ¼ inch in diameter serve as bus bars. These are held on the upper edges of the glass sides by means of a spring clamp at each end. Shallow cross grooves are filed in each bar 1½ inches apart to keep the electrodes properly spaced.

The electrodes are riveted to strips of sheet copper, which are passed over and soldered to $\frac{3}{16}$-inch copper supporting rods. This is shown in the electrode drawing Fig. 4. A piece of rubber tubing is slipped over one end of each support bar to insulate it from one of the bus bars. By this method the bus bar on one side of the vat will have contact with all the anodes and be insulated from the cathodes while the reverse condition will prevail on the opposite side of the vat.

The cathode bus bar of one vat connects with the anode bus bar of the next vat, etc.

The electrolyte overflows through a lead spout from the upper vat into a lead pipe, which conducts it to near the bottom of the next vat. In a similar way it passes through the five depositing vats to a sixth vat, from which it is siphoned to the well of a Pohle air lift delivering to the upper vat. The rate of circulation can be varied at will by adjusting the air lift.

In the class work it is customary to operate the plant at ten to fifteen amperes per square foot of cathode surface and two-tenths to four-tenths volt between electrodes. No attempt has been made to heat the electrolyte, but this could probably be done if desired. The vats have been used only for depositing copper, but there is no apparent reason why they could not be utilized for work on other metals.

The only difficulty encountered thus far has been the tendency of the acid to eat the slate at the surface of the electrolyte. This has been prevented by coating with acidproof paint.

In operating the plant the students make all necessary electrical observations, weigh the cathodes before and after the test, sample the electrolyte before and after the test, note the rise in temperature of the electrolyte, etc. At the close of the test the electrolyte is siphoned into glass carboys and the anode mud cleaned out, dried and weighed. After the necessary analyses an account of stock of copper, arsenic and precious metals is made, the electrical efficiency calculated and a neostyle sheet prepared giving in tabulated form all data and calculations.

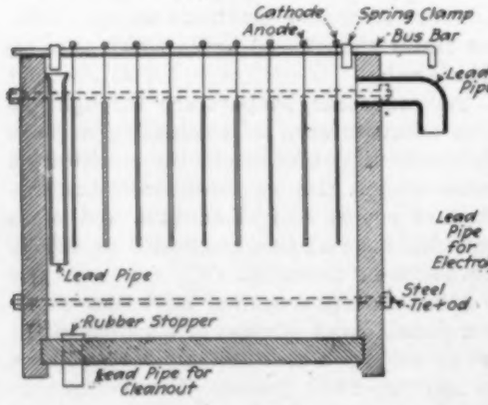

FIG. 2. VERTICAL SECTION OF VAT

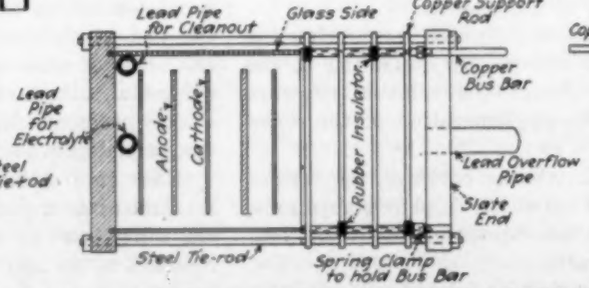

FIG. 3. COMPOSITE SECTION AND PLAN OF VAT

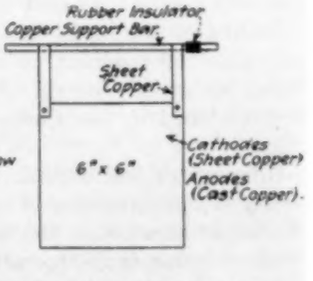

FIG. 4. ELECTRODE

Fuel Economy in the Boiler House—II

A Description of the Types of CO_2 Recorders Used in America and Europe and Principles Involved in Their Operation—Sarco, Uehling, Simmance & Abady, Cambridge Bi-Meter, Auto and Mono-Recording Instruments

By JOHN B. C. KERSHAW

In the previous article[1] the writer showed how important was regular and systematic testing of the waste gases from boiler plants, in connection with the urgent need for economy in the use of fuel, and also pointed out that automatic gas-testing apparatus could be of great service in assisting the boiler engineer to obtain the highest possible efficiency from his plant. The best method of connecting the testing apparatus to the boilers and flues was then described, and the need for placing the apparatus in charge of a properly trained man was emphasized. Corroboration of the remarks which the writer made on this subject of skilled supervision is found in an article which was published in an English technical journal before the war by a power station engineer, under the title of "CO_2 Recorders in Power Stations." This correspondent pointed out that many of the failures of automatic gas-testing apparatus in the past had been due chiefly to the defects in the installation and management of these machines, rather than the fundamental defects in their design. The advantages of the recording type of apparatus were stated to be:

"(1) That it shows at any and all times the percentage of CO_2 being obtained, so giving a guide to engineers in charge and firemen as to the conditions prevailing in the furnaces; (2) it is an index to the correct thickness of fire under different conditions; (3) it is a guide as to the correct amount of draught to be given to the fires under varying conditions; (4) it is an index of any air leakage at all points between the furnaces and the position in the flues where the gas for analysis is taken from."

The writer is aware that the U. S. Bureau of Mines has published two valuable bulletins, Nos. 91 and 97, dealing with "Sampling of Flue Gases" and "Automatic CO_2 Recorders." He has made some use of the latter bulletin in compiling the descriptions given below, but only five recording types of instruments were tested by Messrs. Barkley and Flagg in their investigations, and are described in Bulletin 91, whereas double this number are on the market and have been used in Europe and America. Since no independent description of the various types of CO_2 recorder has yet been published in this journal, the writer has thought it well to collect in one article the available information on the subject, and below all the leading types of automatic gas testing and recording apparatus are illustrated and described, with notes upon their respective advantages and defects.

The "Ados" or Sarco recorder is the oldest and most widely used form of testing apparatus for obtaining continuous and regular records of the CO_2 contents of the waste gases. Fig. 1 shows the latest form of the Sarco recorder. The power for actuating the instrument is supplied by a fine stream of water with a head of about two feet which enters the tube shown on the right hand side of the figure. The rate of flow, and therefore of operation, can be varied by altering the size of the jet used for the small glass injector. The water admitted gradually fills the measuring vessel shown in the center of the figure, and when it reaches a fixed point on the tube connecting this vessel to the gas supply, the water is automatically siphoned out, and 100 cc. of the gas to be tested are drawn into the vessel. This gas, as the water again rises in the measuring vessel, is forced into the solution of caustic potash (sp. gr. 1.27) contained in the large vessel shown on the left hand bottom corner of the figure, and as the gas bubbles up through this solution, any carbon dioxide contained in it is absorbed. The residual gas now passes up into two tubes containing floats, placed directly above the absorption vessel, and by suitable

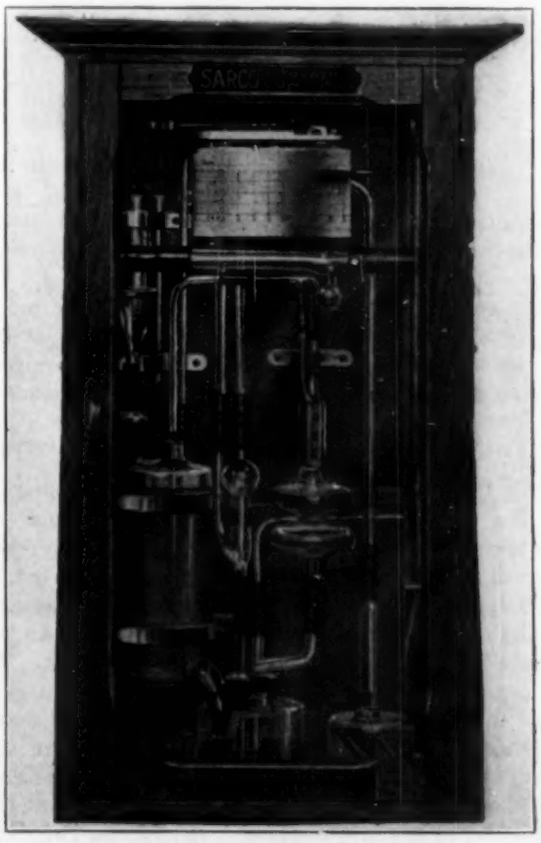

FIG. 1. THE SARCO CO_2 RECORDER

[1] CHEMICAL & METALLURGICAL ENGINEERING, Vol. 20, No. 4, Feb. 15, 1918.

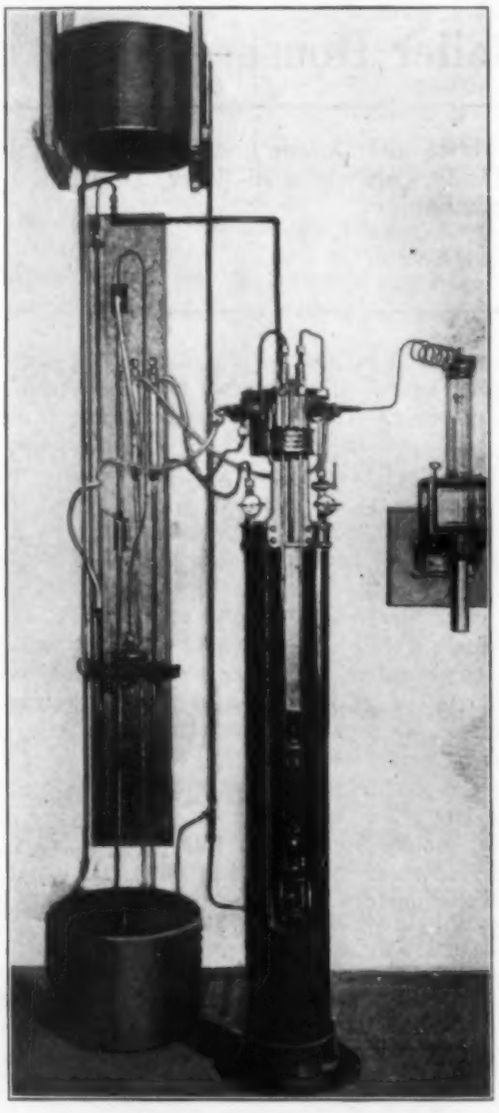

FIG. 2. THE UEHLING GAS COMPOSIMETER

mechanism records are obtained, on the paper attached to the revolving drum, of the volume of the residual gas.

It is customary to arrange the controlling mechanism so that samples are drawn from the flue at intervals of ten minutes, and the KOH solution requires renewal according to the frequency of the tests made.

The Uehling Continuous Gas Composimeter

The Uehling gas-testing instrument is based upon the law which governs the flow of gas through small apertures. The gas-containing vessels of different capacities are placed in connection with a steam-jet aspirator and with the flue. The apertures connecting the smaller vessel with the other, and the second or larger vessel with the flue, are small and of equal size. When the aspirator is set to work, a partial vacuum is produced in both vessels, consequent upon the fact that gas is being drawn out of them more quickly than it can enter, and the vacuum as measured by manometers attached to each vessel is found to be twice as great in the smaller as in the larger vessel. If now the gas passing through the larger vessel be submitted to the action of a solvent which absorbs and withdraws one of its constituents, the vacuum in the second chamber or vessel will be increased and the difference between the partial vacuum in the two vessels will be diminished in like ratio. The absorption of CO_2 from furnace gases by caustic potash can therefore be utilized to cause differences in the pressure ratio in the two gas vessels, and by proper calibration a means for ascertaining the percentage of CO_2 in the gases is obtained.

To embody this principle in a practical apparatus the following conditions must be fulfilled: (1) The gas must be brought into the apparatus under a constant tension, and must be drawn through the two apertures with a continuous and uniform suction. (2) Both apertures must be located in a part of the apparatus which is maintained at a constant temperature. (3) Provision must be made for keeping these apertures perfectly clean. (4) The larger chamber must be made perfectly gas-tight. (5) The constituent to be absorbed (CO_2) must be entirely removed while the gas is passing through this part of the apparatus.

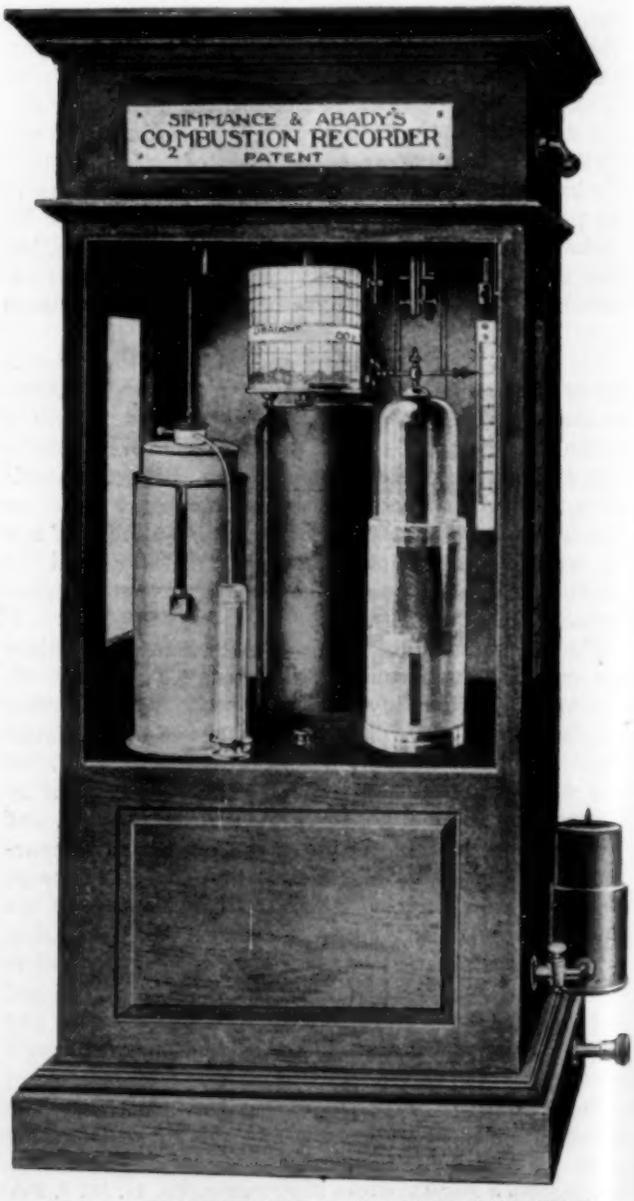

FIG. 3. THE SIMMANCE & ABADY CO_2 RECORDER

The Uehling instrument is made in two forms, the first with, and the second without, a recording pen and drum. Fig. 2 illustrates the latter type.

The Simmance-Abady Recorder

The Simmance-Abady recorder is illustrated in Fig. 3, and in some of its features resembles the "Sarco" apparatus, for water supplies the motive power and the CO_2 is absorbed by bubbling through a solution of caus-

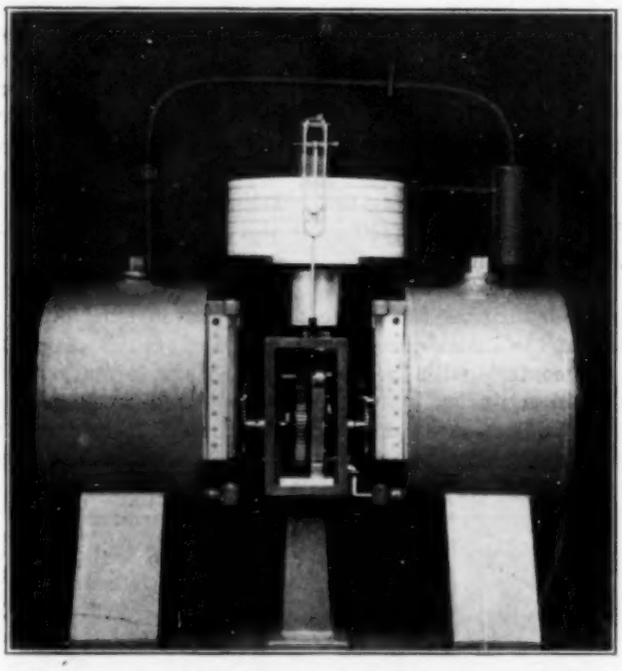

FIG. 4. THE CAMBRIDGE BI-METER CO_2 RECORDER

tic potash, contained in a steel vessel enclosed in the lower portion of the case which contains the apparatus. About 600 cc. of the flue gases are drawn from the flue at definite intervals of time, and a measured portion of this volume is employed for each test in that portion of the apparatus called the "analyzer." When the flue gas has been transferred from the "extractor" into the "analyzer," the CO_2 is absorbed, and owing to such absorption the analyzer bell will not rise to its full height. It is allowed to work automatically and to rise as far as it will, where it remains for a few seconds and then drops a little, as the heat of the chemical combination disperses and the absorption is completed. At this point a pen descends, and marks downward from the zero on the chart to the position of the analyzer bell.

A boxwood scale on the side of the recorder tank is graduated to show 100 per cent CO_2 at the bottom and 0 per cent at the top. The capacity of the bell shown on the left in the figure is such that when the test is made with air the whole of the sample is transferred to the recorder bell on the right, which then rises to the zero point on the scale. When a sample of flue gas is admitted into the appa- extractor bell through the analyzer vessel into the recording bell, but owing to the absorption of CO_2, this bell does not rise up to its full height, and the deficiency is registered by the fall of the pen to the point reached by the top of the tank. The bell then discharges its residual gas, and sinks to its original position in readiness for a new charge of gas, minus its CO_2 contents.

The Bi-meter CO_2 Recorder

The principle upon which the Bi-meter CO_2 recorder is based is that of measuring the flue gas, before and after the absorption of CO_2, by two ordinary gas meters, the actual absorption occurring in a vessel containing caustic lime, and the temperature of the gas before and after absorption being controlled by water cooling, in order to eliminate errors due to the difference in volume caused by temperature changes. Fig. 4 shows the appearance of the instrument. The gas is drawn through the apparatus by means of an aspirator, and the difference between the speeds of the two gas meters provides a measure of the amount of CO_2 in the gas. These meters are connected by a differential gearing to the mechanism that actuates the recording pen. After a certain definite volume of gas has passed through the first meter, the pen is made to drop to its initial position, from which it starts to rise again at a speed dependent on the proportion of CO_2 absorbed. The maximum number of tests per hour possible with this type of recorder is 25, and the number can be lowered by reducing the volume of gas passing through the meters. The record chart for 24 hours is 15 inches long, and the drum carrying it is seen in the center of the figure.

The Auto-Recorder

The auto-recorder is shown in diagrammatic form in Fig. 5 and, like the two first described, the instrument depends upon a stream of water for its motive power

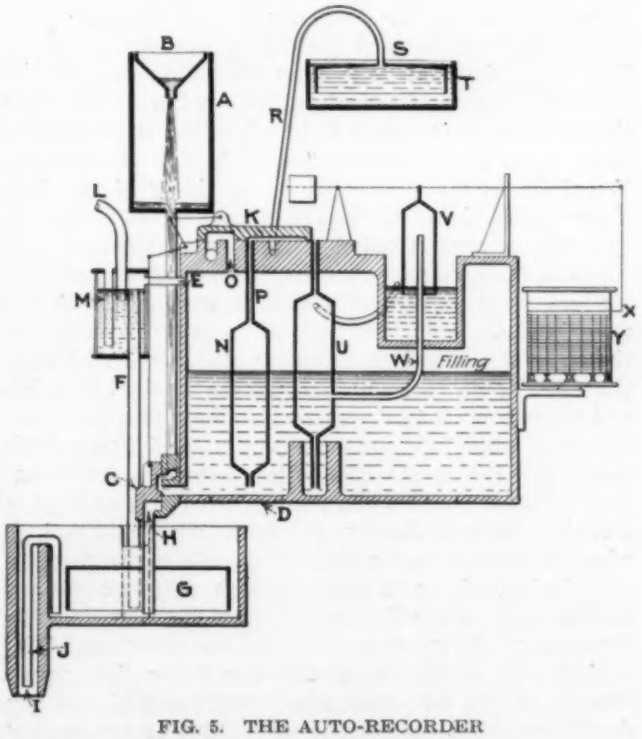

FIG. 5. THE AUTO-RECORDER

and upon caustic potash as the absorption chemical. The water enters the apparatus by the funnel *B*, and passes down into the large vessel *D* through the sliding valve at *C*. When the chamber *D* is quite filled with water.

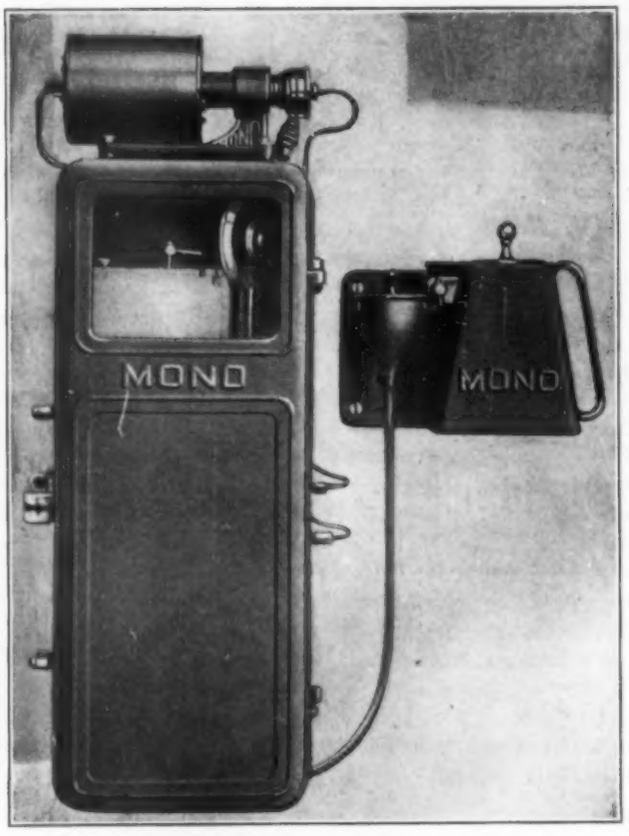

FIG. 6. THE MONO AUTOMATIC CO_2 AND CO RECORDER

this overflows by the pipe *E* into the vessel *M* and thence into the lower vessel containing the float *G*, and the consequent rising of this float causes two motions which start and carry forward the testing operation. In the first place, the float as it rises pushes up the valve *C* and closes the water supply at this point, at the same time opening the passage *H*, by which the water escapes from *D* and draws in a sample of the flue gas through *E* and *I*. In the second place, the rising of the float *G* causes the sliding valve at *K* to move to the right, and puts the measuring vessel *N* into communication with the tank *D*, through the passage *O*, so that a sample of the gas passing into *D* is also drawn into *N* as the water sinks. When the tank *D* is quite emptied, the siphon at *J* comes into operation, and, by discharging the water from the lower tank, causes the float *G* to fall and the valves *C* and *K* to return to their first positions. *D* and *N* therefore are now slowly filled again with water, and the surplus gas in the former is forced out into the atmosphere, while the measured volume in *N* is forced up through the pipe *R* into the absorbing tank *T*, where it collects under the bell *S*, and is speedily deprived of its CO_2 by the caustic potash solution contained in this tank. When the tank *D* again overflows and the discharge of the water again causes the movement of the sliding valve at *K*, the residual gas under *S* is drawn through *R* into the second measuring vessel *U*, and any deficiency of gas required to fill *U* (due to the absorption of CO_2) is made up by withdrawal from that contained in the bell *V*, suspended from a weighted lever to which is attached the recording pen at *X*. The downward movement of this lever after each test is completed therefore gives a measure of the percentage of CO_2 in each sample of gas drawn into *N*, and is recorded on the clockwork drum chart shown at *Y*.

THE MONO RECORDER

The Mono recorder differs from those previously described in the fact that it is a combination CO_2 and O recorder and may be used for either gas, while by the addition of a further appurtenance it is possible to make the instrument record the percentage of carbon monoxide. The power which actuates the mechanism of the instrument is derived either from compressed air or water, mercury being employed in the measuring portions of the apparatus, where the gases come into contact with the fluid medium. The gas, after being cooled and measured, is deprived of its CO_2 by bubbling through a caustic potash solution contained in the tank, shown in Fig. 6. The residual gas then passes up into the measuring bell, which actuates the recording mechanism, precisely as in the Sarco and Simmance-Abady instruments.

When it is desired to record oxygen, the gas stream is made to pass through an electric oven fixed on the top of the instrument, in which the oxygen is brought into contact with heater carbon, with formation of CO_2 in equivalent amount. The gas issuing from the oven is then cooled and passed through the remainder of the apparatus as before, the difference of the two

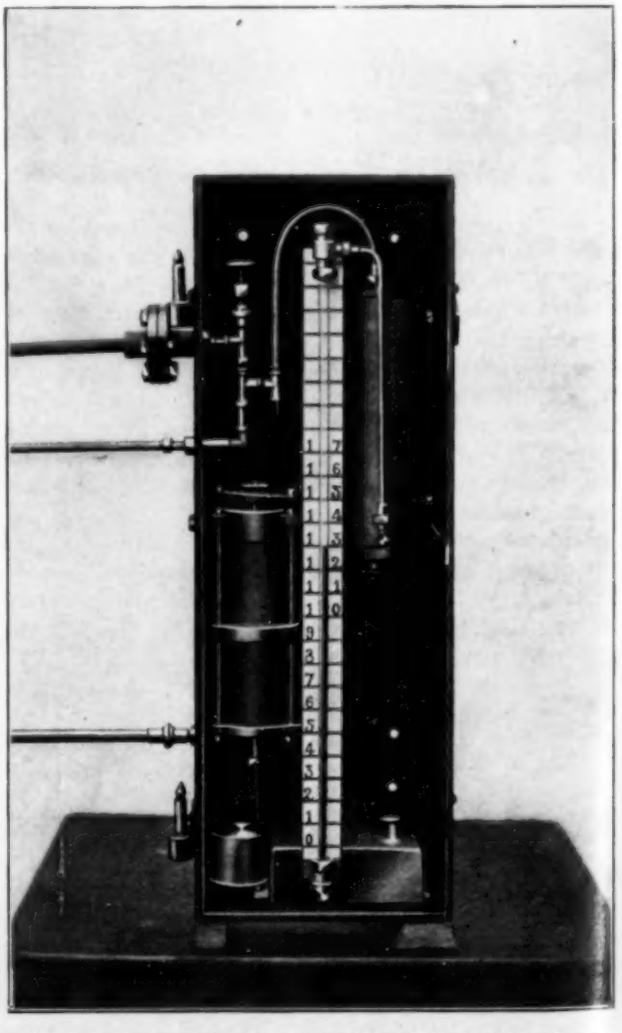

FIG. 7. THE WEBSTER W. R. COMBUSTION INDICATOR

consecutive tests giving the percentage of oxygen contained in the gas. Carbon monoxide is determined in the same manner. This method of estimating the oxygen and carbon monoxide, however, is dependent upon there being no other gases present which will combine with carbon at a red heat, and a mixture containing hydrocarbon gases, carbon monoxide, carbon dioxide and oxygen cannot therefore be analyzed in this manner.

The Webster W. R. Combustion Indicator

As its name implies, the Webster W. R. combustion indicator is not a recording apparatus, but gives a continuous reading of the CO_2 present in the boiler or chimney gases. Fig. 7 is a diagram illustrating the principle upon which this CO_2 indicator works. A water or steam aspirator (on the left) draws the flue gas continuously through the instrument, and after passing through the filter the gas enters a chamber containing a porous pot charged with a solid absorbing medium, for CO_2 gas. This chamber and pot are connected, as shown, by two vertical pipes, or tubes, with a vessel containing water, and the difference in pressure between the gas in the outer chamber and that inside the pot, due to the absorption of CO_2, causes the water to rise in the pipe that connects the porous pot with the water tank. By aid of a graduated scale attached to the latter pipe, the percentage of CO_2 can be read off directly, $\frac{7}{8}$ of an inch in height being taken as equal to 1 per cent CO_2. The "indicator" is said to respond quickly to any changes in the composition of the flue gases, and if placed in a position where the fireman can see the fluctuations of the water column, it provides him with a useful help to the efficient control of his fires. The cartridge containing the solid absorbent is said to require renewal only every other day, but the period for which it will act efficiently depends, of course, upon the CO_2 contents of the waste gases.

Eliminating Phosphorus and Sulphur in Electric Ferromanganese Furnaces

By Jay Lonergan

IN HIS discussion of the paper of Robert M. Keeney, presented at the Colorado Meeting of the American Institute of Mining Engineers, H. W. Gillett mentions the fact that recent experiments have indicated that it may be possible to eliminate a large proportion of the phosphorus from high-phosphorus manganese ores. It is thought that it would be interesting to the producers of ferromanganese to have published the methods which have been tested, and in this respect the following notes may be of value.

When the first furnace of the Iron Mountain Alloy Co. was started an attempt was made to smelt a high-phosphorus ore by carrying an excess of lime. This run lasted several days and was a failure. The ore contained about 0.32 per cent phosphorus, and the resulting ferromanganese about 0.6 per cent phosphorus. After this trial, all high-phosphorus ore was mixed with sufficient low-phosphorus ore to give a charge with a phosphorus content of about 0.15 per cent. With a mix of this nature no trouble was experienced in keeping the phosphorus content of the ferromanganese under 0.25 per cent, the maximum limit set by consumers.

A test has just been completed, however, which had the object of determining the proportion of both phosphorus and sulphur which can be eliminated by ordinary practice. This test will partially answer Mr. Gillett and others interested in such questions. The results are given in Tables I and II. Table I gives the analysis and make-up of the charge used, while Table II gives the resulting products from this run. Column 7, Table II, shows that 52.6 per cent of the phosphorus is retained by the metal, while the unaccounted losses (obtained by difference) show that 31.4 per cent is carried off through the ventilators.

While no tests have been made to determine the proportion of mechanical and volatilization losses, from observation I should say that the greater part is a purely mechanical loss, therefore the phosphorus in the dust is still retained in its original form. In case the phosphorus were volatilized it would probably indicate its presence by PH_3 gas, poisoning some of the furnace men. To date there have been no cases of poisoning.

Using the results of the above test and determining the maximum allowable percentage of phosphorus in a manganese ore to produce a metal containing a maximum of 0.25 per cent phosphorus, it took 2830 lb. dry ore to make 1000 lb. ferromanganese. On the basis that 52.6 per cent of the total phosphorus charged will go with the metal, no more than $4\frac{3}{4}$ lb. phosphorus can be carried in 2830 lb. ore and about 1760 lb. coal and lime.

Assuming that the latter contains 0.34 lb. phosphorus, the ore can contain 0.17 per cent. This figure is substantiated by the results of several months' run of the furnace previously mentioned.

Column 4, Table II, shows that at least 98 per cent of the sulphur in the charge is eliminated.

TABLE I. FURNACE CHARGE

	1 Weight in Lb.	2 Per Cent. S.	3 Lb. S.	4 Per Cent. P.	5 Lb. P.
Lot 305 ore	5,000	0.081	3.847	0.023	1.092
Lot 314 ore	5,000	0.111	5.272	0.015	0.712
Lot 220 ore	20,000	0.245	44.100	0.036	6.480
Lignite coal	11,812	0.398	47.011	0.004	0.472
Lime rock	5,500	0.046	2.530	0.050	2.750
Total	.....	.....	102.760	.....	11.506

TABLE II. FURNACE PRODUCTS

	1	2	3	4	5	6	7
		Sulphur			Phosphorus		
	Weight in Lb.	Analysis per Cent. S.	Weight Lb. S.	Per Cent. of Total Charged	Analysis per Cent. P.	Weight Lb. P.	Per Cent. of Total Charged
Metal	9,828	0.012	1.179	1.148	0.056	5.503	52.6
Slag	12,137	0.293	35.561	34.60	0.014	1.699	14.75
Dirty metal and slag	2,490	0.200	4.980	4.75	0.028	0.697	6.06
Unaccounted for in dust and volatilization. Losses (by difference)	.....	.....	61.04	59.40	.....	3.607	31.40

Iron Mountain Alloy Co.,
Denver, Colo.

Determining Zero Reading on an Ellison Gage

BY HERMAN BACHARACH

In the September 1 issue of CHEMICAL & METALLURGICAL ENGINEERING is a very interesting article by Mr. Evald Anderson on a method of determining the zero reading of an Ellison gage without disconnecting it. The necessity of making this determination is clearly explained and the method is, no doubt, a very good one for portable instruments, but in a permanent installation

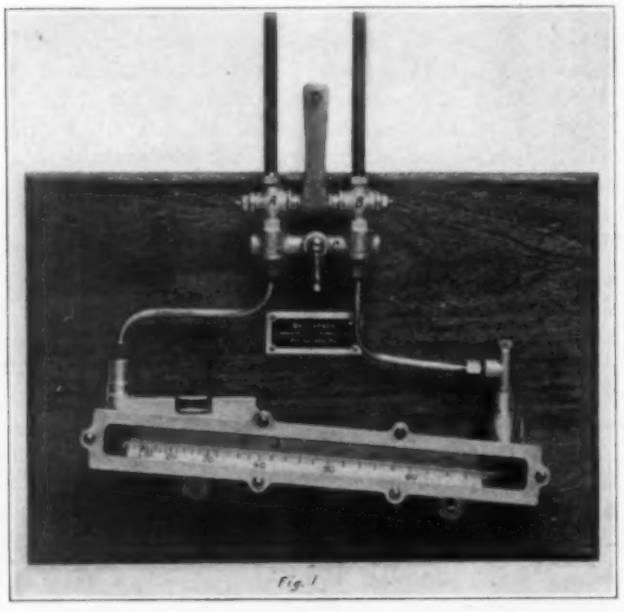

FIG. 1. GAGE READY TO ATTACH THE PRESSURE LEADS

it might be well to make provision for getting the zero reading at any time by using the proper valve and pipe connections instead of rubber tubing and a clamp.

It would probably interest your readers to know of an instrument comprising a gage properly connected and mounted on a board ready to attach the pressure leads, as shown in Fig. 1.

The valves *A* and *B*, Fig. 1, are closed simultaneously by lever *D*, and cock *C* is then opened. The oil will then come to rest at the zero position. After this position is noted, the valves *A* and *B* are opened and cock *C* closed, thus placing the gage in operation. Since the two pressure leads are closed when the zero position is being determined, there is no danger of the differential pressure having any influence on the reading and also, since the operation of these valves is simultaneous, the liquid will not be forced out of the gage. The gage may be calibrated to read velocity or volume.

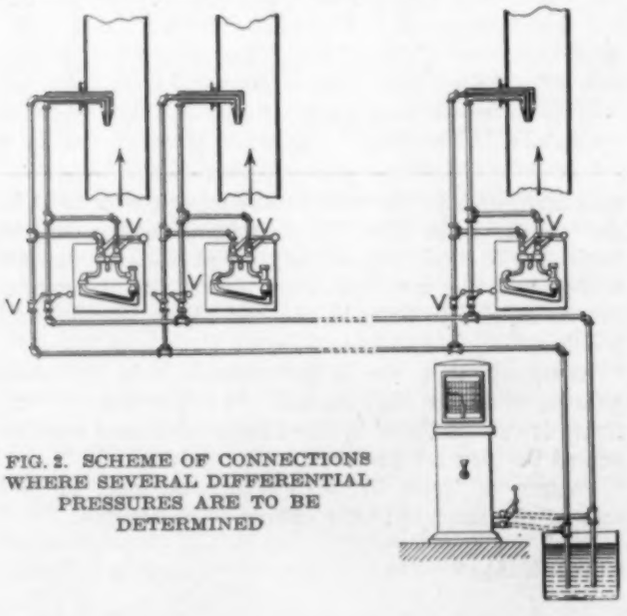

FIG. 2. SCHEME OF CONNECTIONS WHERE SEVERAL DIFFERENTIAL PRESSURES ARE TO BE DETERMINED

Fig. 2 shows a scheme of connections where several differential pressures are to be determined. Gages may be used as shown and placed where they may be easily seen by the operators. A recording instrument can be placed anywhere near, perhaps in the superintendent's office, and any one of the differential pressures recorded by the proper arrangement of the link valves *V*. The zero reading of the gages can be taken as described above, Fig. 1.

Points in Pump Selection*

BY B. N. EVERETT

PUMPS as a rule have very high load factors; that is, ratio of power consumed to maximum demand is high. Also, the power consumption per dollar invested in the apparatus is higher than in most other power-consuming equipment. It would appear, therefore, that the matter of power consumption should be given consideration, especially when the variation of power requirements of different pumping arrangements is so great.

The fact that exhaust steam from direct-acting pumps may often be used to heat feed water has led to the habit of assuming that steam economy is of little importance. But which is the better economy—to use efficient pumps and let water enter the boilers considerably below the boiling point at times, or to allow heat to escape to the atmosphere because of an excess of exhaust steam from inefficient pumps? In the first case the deficiency in feed temperature must be made up by fuel and in the second case fuel is burned to generate the steam that passes through the pumps and heats the feed water and also the steam going to waste.

The word "efficiency" as ordinarily applied to pumps is of little value. For instance, a steam pump with an efficiency of 80 per cent (that is, the indicated horsepower of the water end is 80 per cent of the indicated horsepower of the steam end) was replaced with an electrically driven triplex pump with an over-all efficiency of 70 per cent (that is, the water horsepower was 70 per cent of the horsepower supplied to the motor). The electric pump was driven through the medium of an efficient engine and generator and required only 6 lb. of fuel per 1000 gal. pumped, whereas the steam pump required 42 lb. of fuel per 1000 gal. pumped, which is a difference of several hundred per cent. In this particular case besides the reduction in fuel consumption one man's labor was saved, as the steam was supplied from a separately fired boiler.

The accompanying chart gives the principal points to be considered by an engineer in selecting a pump. No one but an engineer with a knowledge of various classes of pumping machinery and all the individual

*Power, Sept. 24, 1918.

requirements of the plant should handle the matter. The various items are so interdependent that all must be borne in mind while each is considered individually.

The character of the liquid to be pumped has a direct bearing on the size of pipe to use, the advisable speed, the suction lift of the pump and the power required.

CHART SHOWING POINTS TO BE CONSIDERED IN THE SELECTION OF A PUMP

- Liquid to be pumped...
  - Specific gravity
  - Temperature
  - Viscosity
  - Size and nature of solids
- Total head.....
  - Suction lift or head.....
    - Size of pipe
    - Vertical distance
    - Suction-pipe friction
  - Discharge head.....
    - Size of pipe
    - Vertical distance
    - Discharge-pipe friction
- Capacity.....
  - Maximum demand
  - Average demand
  - Storage capacity
  - Breakdown service
  - Hours service per day or per year
  - Advisable speed
  - Source of liquid
- Power.....
  - Available
  - Time of operation
  - Reliability
  - Required
  - Control
  - Estimated cost.....
    - Per 1000 gallons
    - Per month or year
    - Compared to investment
- Cost....
  - Initial ....
    - Pump
    - Driver
    - Piping
    - Installation.....
      - Location
      - Space required
  - Operating..
    - Labor
    - Power.....
      - Use of exhaust steam
      - Efficiency
      - Transmission losses
      - Cost per 1000 gallons pumped
    - Fixed charges
      - Cost per day or year
      - Fuel consumption

Hot water must flow to the pump under a head. Pumps handling sewage, sand, etc., need special features.

In deciding on the size of pipe to use, each of the following should be considered: Liquid to be pumped, total friction head of pipe and fittings, maximum capacity, average demand, hours service per day, per year, etc., and cost of power. It is a problem of balancing the cost of power consumed to overcome friction against the cost of the line installed. It is somewhat analogous to figuring the size of an electric transmission line. It requires power to overcome friction in proportion to the amount of liquid pumped and the extra first cost of a larger size of pipe will often be returned in saving in power in a short time.

Some time ago data sheets giving the friction of water flowing through pipes and elbows were revised by pump manufacturers because they did not agree with practice. Pipes soon get scaled up inside and offer more resistance than when new.

When a pump is pumping to a system direct, without any storage provided, it must be large enough to meet the maximum demand. Care should be taken that no loss of time is incurred through lack of pump capacity. A woolen mill had a number of machines that required filling with liquid periodically. They were served by a pump that required ten minutes at each filling. It was shown that the output could be increased by reducing this period to two minutes. A pump of the required capacity would have five times the displacement of the old pump, which was of ample capacity to supply the average demand of all machines. So, by installing a storage tank of a capacity to meet the maximum demand the filling period was reduced to less than two minutes. Besides, power was saved by reducing the many starting and stopping periods.

Sometimes two pumps can show better economy than one. A manufacturing plant was using water for all services by pumping from artesian wells to a tower tank under a total head of 120 ft., and the water requirements had outgrown the capacity of the pump. Approximately half of the water was used for cooling gas engines and air compressors in the power plant, for which service a head of 30 ft. was ample. A separate pump and control tank were installed and the power required to pump water was reduced 30 per cent, at the same time increasing the pumping capacity for future requirements.

The calculations of the actual power consumption of a pump should include all the power used or necessarily wasted. The heat lost by radiation and valve leakage in keeping a pipe line and steam pump warm and ready for service often amounts to considerable per 1000 gal. pumped. A belted triplex pump, even with an efficiency of 80 per cent, if controlled by a bypass valve, may be consuming power at its maximum rate and actually delivering only a small percentage of its capacity.

As a general rule direct-acting steam pumps should be employed only where use of all the exhaust steam is possible, or where service is intermittent and better economy will not warrant a larger investment. Steam-valve leakage often amounts to an enormous total, and pump slippage is often a more formidable loss than is suspected. Consider a direct-acting steam pump supplying an average demand equal to 30 per cent of the normal capacity of the pump, pump slippage at normal rate amounts to 15 per cent, and the pump is controlled by a throttling type pressure control valve. Then the slippage (15 per cent of capacity) amounts to 50 per cent of the discharge (30 per cent of capacity) and the steam consumption due to slippage is 50 per cent instead of merely 15 per cent. Under these conditions also the radiation losses and valve leakage amount to more per 1000 gal. pumped. So it is often the case that the power consumption per 1000 gal. pumped is more than double what would be indicated at a normal speed.

Tilting pumping traps are used extensively in handling condensation and feeding boilers, and very low steam consumptions are obtained when pumping hot water. Tests showing steam consumption when pumping cold water would be interesting.

In a certain plant that used a great number of steam pumps, serving evaporators, washers, coolers, etc., the pumps were allowed to run without oil and at destructive speeds and abused generally. Production was interrupted almost daily in one department or another by pump trouble and the pump repairman's hair was gray. The chief engineer said that although he could use the exhaust from the pumps, he was installing single-stage centrifugal pumps direct-connected to electric motors in every case where they could be applied, simply because they are more fool-proof and increase the factor of safety against interruption of service.

In the case of centrifugals even greater care should be taken in making the application, especially in regard to the correlation of total head and peripheral speed of impeller to the motor speed, and the means of regulating capacity.

Recent Chemical and Metallurgical Patents

Magnesian Furnace Refractories

Magnesium Oxide from Dolomitic Rock.—A. M. MITCHELL of Tuckahoe, N. Y., patents a process of separating magnesium oxide to be used in the manufacture of refractories from mixtures of magnesium and calcium carbonates commonly called dolomitic rock. The ground rock is charged into a tube mill, set into a furnace and heated externally to about 950 deg. F., at which the CO_2 is driven off from $MgCO_3$, but which is too low to decompose the $CaCO_3$. During calcination the material is finely ground, thus separating the minute particles of magnesite and calcite. After calcination the calcite remains in its original shape, crystalline and compact, while the magnesite has been converted into MgO, which is powdery and light. Separation of these two materials may then be effected by well-known gravity concentrators. (1,273,110; assigned to Mitchell & Grenelle; July 16, 1918.)

Furnace Lining.—S. R. NEWBERRY of Cleveland, Ohio, patents the following method of burning dolomitic limestone in order to prepare a refractory material which will not air-slack. He takes a dolomitic limestone as free as possible from silica, and wet-grinds to 100 mesh together with from 2 to 5 per cent of bauxite, iron ore or some substance containing oxides of the aluminium-iron group. These amphoteric bases form very fusible compounds with the lime, and but a small percentage is required to properly "fix" the lime so that it will not form hydrates. The slurry is burned at from 2700 to 3000 deg. F. in a cement kiln, the temperature depending upon the nature and quantity of the addition, and the resulting clinker crushed to required size for sale or for the formation of refractory brick. (1,267,686; May 28, 1918.)

J. O. HANDY and R. M. ISHAM of Pittsburgh, Pa., produce a furnace lining material from dolomitic or magnesian limestones in somewhat the same manner. Their fluxing agent is calcium chloride, or in case the material is nearly pure MgO, magnesium chloride is better. Preferably the crude material, crushed to 20 mesh, is mixed with sufficient brine or bittern so that the dried material will contain about 10 per cent of the chloride. This is then dried to a coherent mass and burned in a rotary kiln at 1500 deg. C. During this operation the chloride decomposes if sufficient water vapor is present from the products of fuel combustion or otherwise and forms hydrochloric acid which passes off with the furnace gases. The resulting clinker contains but fractional percentages of chlorine, and is available for making furnace linings or refractory bricks. (1,270,818; assigned to A. S. Davison Co.; July 2, 1918.)

Artificial Magnesite.—J. O. HANDY and R. M. ISHAM of Pittsburgh, Pa., prepare an artificial magnesite claimed to have the desirable refractory qualities of imported crude magnesites. They calcine a dolomite in a rotary kiln so as to remove all the carbon dioxide without "dead burning." The calcine, granulated to the size of a pea, is leached with cold water to remove the calcium oxide down to from 3 to 10 per cent. Additions of basic slags and clays are then made and the material is re-burned at 1550 deg. C. to remove the water of hydration and carbon dioxide. The final product should have 85 to 88 per cent MgO, lime 3 to 10 per cent, silica 4 to 8 per cent and a little iron and alumina. The small amount of lime is necessary for bonding, yet is so small that danger from slacking is absent. (1,270,819; assigned to A. S. Davison Co.; July 2, 1918.)

High-speed Steel Substitutes.—P. R. KUEHNRICH of Sheffield, Eng., notes that cobalt has been used as an ingredient of many alloy steels and that carbon-chromium steels are known to be much superior to plain carbon steel tools, although they do not possess the quality of red-hardness until cobalt is added, which fact constitutes his invention. He recommends a composition approximating

C	1.5 per cent
Cr	12.0 per cent
Co	3.5 per cent
Si	0.3 per cent
Mn	0.2 per cent

with up to 1 per cent of any of the other metals of the chromium group. (1,277,431; Sept. 3, 1918.) G. L. KELLEY and A. H. MILLER of Germantown and Ambler, Pa., claim especial toughness as well as hardness by the addition to nickel of from 0.5 to 2 per cent of zirconium, which is less than previously recommended, when accompanied by aluminium and silicon. The sum of the last two ingredients should be at least 8 per cent; they are equivalent to a certain extent, but the content of aluminium or silicon should not fall below 2 per cent or go above 8 per cent. (1,258,227; Mar. 5, 1918; assigned to Midvale Steel Co.) H. S. COOPER of Cleveland, Ohio, patents a composition very similar to the above. He presents diagrams showing that at least 10 per cent aluminium must be added to nickel to give a scleroscopic hardness greater than 55, which is necessary for a cutting tool. More aluminium, while increasing the hardness, cuts down the already deficient toughness. Another diagram shows that if 2 or 3 per cent silicon be added to the Al-Ni alloy, the hardness is still sufficient, while the grain is finer, and the toughness increased. Adding from 1 to 15 per cent zirconium to the ternary alloy gives the mixture red-hardness and great toughness and forms an excellent cutting tool. Chromium group metals may be added to the quaternary alloy with advantage—tungsten especially increases the life of the tool. These alloys melt at a low temperature and can be cast to shape and ground into a tool. No heat treatment is required. The alumino-thermic method of reduction of the constituent oxides is recommended for the production of the pig metal. (1,227,046, Aug. 27, 1918, and 1,278,304, Sept. 10, 1918; assigned to the General Alloys Co.)

Manufacture of Acetic Acid.—HENRY DREYFUS of Basel, Switzerland, patents processes of making acetic acid, which comprise passing a mixture of acetaldehyde and oxygen over a catalyst at a temperature between the boiling point of acetic acid and 400 deg. C. (1,286,255-1,286,256).

Ferro-molybdenum Manufacture.—E. H. WESTLING and CARL ANDERSON of San Francisco patent the process of making ferro-molybdenum from ferric molybdate by reducing the latter with carbon or hydrogen at a comparatively low temperature (less than 900 deg. C.), producing a spongy product which does not oxidize easily, and which is assimilated in a steel bath with the utmost facility. The ferric molybdates may be precipitated from soluble alkaline molybdates by ferric sulphate or from soluble molybdenum salts by the same reagent after neutralizing the solution with alkaline carbonates. With a minimum of iron, a yellow $Fe_2(MoO_4)_3$ is formed, while with excess a brown $Fe_2O_3 . MoO_3$ results. By properly mixing the two a ferro with any desired composition between the limits may be produced. (1,278,408; Sept. 10, 1918.)

Ferro-phosphorus and Cupro-phosphorus.—H. A. WEBSTER of Columbia, Tenn., finds that if a proper mixture of iron phosphate, coke and limestone is heated to from 1000 to 1500 deg. C. in a rotary kiln, the interior of the furnace becomes lined with incandescent carbon which materially hastens the reaction. The products—an iron phosphide containing 25 per cent phosphorus and a slag—may be granulated and separated by a magnetic separator. The gasified phosphorus may be largely retained in the nodular phosphide by charging iron filings with the mixture. The proportion of phosphorus in the compound may be increased to 30 per cent by heating the same mixture in a closed furnace at three atmospheres, cooling the melt under pressure to the liquidus and then tapping the contents. (1,264,236 and 7; April 30, 1918.) L. A. JEFFS of Salt Lake City, Utah, patents the process of making cupro-phosphorus in a furnace similar to the Stassano. He charges phosphate rock, oxidized copper ore and a large excess of carbon, together with the necessary flux. The reduced copper trickles down through incandescent carbon against an upward stream of phosphorus and CO, and the cupro-phosphorus formed collects in the crucible below the slag layer. By using a small percentage of copper the exit gas can be made so rich in phosphorus as to warrant its recovery as the principal product. (1,268,849; June 11, 1918.)

Ferro-silicon.—J. E. JOHNSON, JR., of Hartsdale, N. Y., notes that the large amounts of nitrogen in atmospheric air lowers the maximum temperature in the ordinary blast furnace to a point where a 12 per cent ferro-silicon is the ordinary alloy made. Since the calorific intensity varies approximately inversely as the products of combustion, he claims that the temperature of the focus obtainable with air enriched to 50 per cent oxygen will be high enough so that much larger amounts of silicon will be reduced and a 50 per cent alloy equal to that now produced in electric furnaces will result at a lower cost. Enriched blast will also reduce the cost of the lower grade alloys. (14,547; Reissued Nov. 12, 1918.) GEORGE C. FURNESS of New York notes that the electric shaft furnace with deeply embedded electrodes ordinarily used in commercial production of ferro-alloys requires a charge which at once shall have a low electrical conductivity and a high porosity. In the manufacture of ferro-silicon, which consumes a large proportion of reducing carbon, this material, ordinarily introduced as coke, anthracite or charcoal having a high specific conductivity, tends to short circuit the electrodes along their adjacent sides if charged in sizable lumps. If, however, the carbon is finer, it makes a dense charge which prevents ready escape of the gaseous products of reaction. He therefore patents the use of from 20 to 40 per cent of the total carbon requirements in the form of small-lump bituminous coal, which has a low conductivity and whose evolved gases burning at the top of the shaft minimize the heat losses at that region. (1,284,645; Nov. 12, 1918; assigned to Electro Metallurgical Co.)

Potassium Sulphate From Alunite.—H. F. CHAPPELL of New York City patents the method of separating potassium sulphate from calcined alunite shown in the diagram, Fig. 1. The method depends upon the fact that the sulphate is more than twice as soluble in water at 100 as at 20 deg. C. The boiling solutions in the dissolver are maintained at that temperature by heating make-up liquors in the heat interchanger just after the muffle furnace, as well as by the addition of hot calcine directly into the tank. The filtered hot solutions are passed through a cooling tower against a countercurrent of air, and the crystal bearing mother liquor centrifuged and returned to the dissolver. Evaporation and other losses are made up with wash water from the alumina filter. (1,268,433; assigned to Mineral Products Corporation; June 4, 1918.)

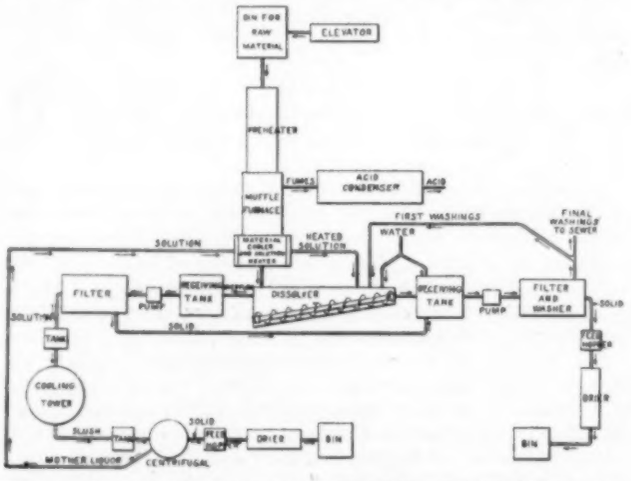

FIG. 1. FLOW SHEET ILLUSTRATING METHOD OF SEPARATING POTASSIUM SULPHATE FROM ALUNITE

Personal

MR. J. CORBUS BUSHNELL, formerly associated with the Business Men's Clearing House, Chicago, Ill., and until recently connected with the U. S. Employment Service as special agent to examine the personnel methods in vogue at Vickers, Ltd., and Woolworth Arsenal, England, has been engaged by the General Engineering Agency, Pittsburgh, Pa., as personnel director.

MR. H. L. GREENE has been appointed chief metallurgist of the Willys-Overland Co. of Toledo, Ohio, and its allied companies.

MR. J. O. LEWIS, superintendent of the petroleum experiment station at Bartlesville, Okla., has just been appointed chief petroleum technologist of the Bureau of Mines, Department of the Interior, in place of MR. CHESTER NARA-

MORE, who has resigned from the Government service to join the Union Petroleum Co., with headquarters at Philadelphia, Pa. Mr. Lewis will be succeeded at Bartlesville by Mr. W. P. DYKEMA, petroleum engineer of the bureau.

MR. SCOTT LINTNER of San Francisco is now manager of the Ray-Broken Hill Mines at Ray, Ariz.

MR. EDWARD A. MILLER has been appointed as assistant superintendent of the Jersey City plant of the Metal & Thermit Corporation, New York, N. Y. Mr. Miller was one of the pioneers in autogeneous welding and cutting, having established the first oxy-acetylene shop in New York City early in 1908 under the corporate form of the Acetylene Welding Co.

MR. JOHN F. NEALIS, who recently received his discharge from the Aero Observers' branch of the service, is now associated with the Powdered Coal Engineering & Equipment Co. of Chicago as advisory engineer. Mr. Nealis formerly had charge of research work for the U. S. Steel Corporation.

MR. D. A. O'CONNELL has been appointed manager of the Seattle office of Marden, Orth & Hastings Corporation.

MAJOR W. P. PUTNAM of the Ordnance Dept., U. S. A., has returned to Detroit to resume his activities as president and general manager of the Detroit Testing Laboratory.

MR. CHARLES F. QUAINTANCE has retired as secretary and sales manager of the Herold China and Pottery Co., Golden, Colo.

MR. W. S. QUIGLEY, president of the Quigley Furnace Specialties Co., Inc., sailed for Liverpool on the Baltic Feb. 15. He will spend several weeks in England, France and Italy.

MESSRS. J. F. SCHOELKOPF, C. P. HUGO SCHOELKOPF and J. F. SCHOELKOPF, JR., have withdrawn as directors of the National Aniline & Chemical Co., New York, N. Y.

MR. C. C. WALLACE, formerly manager of loading of munitions section of the Stenotype Co., Indianapolis, Ind., is now director of development and service, Powdered Coal Engineering & Equipment Co., Chicago, Ill.

MR. FRANK E. WICKS, consulting engineer, recently resigned as superintendent of mills for the Chino Copper Co. at Hurley, N. M., and has opened an office at 404 Union Oil Bldg., Los Angeles, Calif., where he will specialize in concentration and flotation, crushing and fine-grinding problems and plant management.

MR. HARRY W. WOLFF has recently resigned as general manager of the Rector Chemical Corp., N. J., to take charge of the chemical engineering research laboratories of Dr. Alcan Hirsch, New York City.

Obituary

MR. JAMES H. ALEXANDER, for many years one of the vice-presidents of the Standard Oil Co. before its re-organization, died Tuesday, Feb. 18, at his home in Elizabeth, N. J. He was one of the pioneers in the development of the oil industry in the United States and was closely associated in business with John D. and William Rockefeller, H. H. Rogers and the late H. M. Flagler. Mr. Alexander was born in Toronto, Canada, 84 years ago. He is survived by his widow and three sons.

MR. ERNEST L. GODBE, of Salt Lake City, Utah, died at Bath Lake, Calif., Jan. 16. He specialized in chemistry and metallurgy and for many years was engaged in mining in the Pioche, Nev., district, having been vice-president of the Prince Consolidated Mining & Smelting Co. up to a few years ago. He was 51 years old.

MR. FRANK MORRIS BAUM, retired vice-president and general manager of the Portland Wood Pipe Co., who for eight years was State Senator for Spokane County, Washington, died on Feb. 4 in Pasadena, Calif. Mr. Baum was an associate of the gentlemen who are now the controlling factors of the Continental Pipe Mfg. Co. of Seattle and Portland.

Current Market Reports

The Non-Ferrous Metal Market

Friday, Feb. 21.—No response is being made to liberal price concessions, and producers are beginning to curtail production.

Aluminium:—After March 1 aluminium will be on an open market. That prices will go down is evidenced by sales being reported at from 30c. to 32c. per lb., but a rapid return to prewar prices is not expected. Sheets, 18 gage and heavier, are 42c. Powder, 100 mesh, 70c.

Antimony:—Antimony is in light demand and prices have declined to 7¼c. per lb.

Copper:—Copper has been offered as low as 16c. per lb., but there is no immediate consuming demand and buyers are holding off.

Copper sheets, hot-rolled	lb.	$0.24½—$0.34
Copper sheets, cold rolled	lb.	.25½— .23
Copper bottoms	lb.	.37 — .33½
Copper rods	lb.	.21½— .....
Copper wire	lb.	.19½— .....
High brass wire and sheets	lb.	.20½— .26½
High brass rods	lb.	.19½— .25½
Low brass wires and sheets	lb.	.22½— .28½
Low brass rods	lb.	.23½— .29½
Brazed brass tubing	lb.	.31½— .37½
Brazed bronze tubing	lb.	.36 — .42½
Seamless copper tubing	lb.	.31 — .37
Seamless bronze tubing	lb.	.31 — .....
Seamless brass tubing	lb.	.30 — .36
Bronze (gold) powder	lb.	1.00 — 1.75

Lead:—Five-cent lead has stimulated buying, with a result that prices have gone up to 5.1 to 5.2c.; Sheets, 8c. lb.

Tin:—The U. S. Steel Products Co. has liquidated over half of its 10,000-ton allotment at 72½c.

Zinc:—Spelter has been steadier than usual, showing only a 50c. drop per ton during the last two weeks. New York spot $134.50 and spring futures $127.50 per ton.

OTHER METALS

Bismuth	lb.	$3.20 — $3.65
Cadmium	lb.	1.40 — .....
Cobalt	lb.	2.50 — 3.50
Magnesium	lb.	1.75 — 2.10
Mercury	75 lb.	85.00 — .....
Mercury	lb.	1.95 — .....
Nickel	lb.	.40 — .45
Tungsten	lb.	Nominal
Iridium	oz.	175.00 — .....
Palladium	oz.	115.00 — .....
Platinum	oz.	100.00 —105.00
Silver	oz.	1.01½— .....

The Iron and Steel Market

Production of steel ingots during January was at the rate of about 41,700,000 gross tons a year, this being about 85 per cent of capacity, which may be estimated at 49,000,000 tons per annum. The January rate was 3.8 per cent under the average rate in November and December and about 10 per cent under the maximum rate ever attained, which was in September, 1918, about 46,800,000 tons.

The rate of production has been declining continuously since just before the Christmas holidays. No close estimate for the month of February can be made, but the monthly report will probably show something in the neighborhood of 75 per cent for the month. The month closes with a rate much below the opening rate.

Mills have operated at widely divergent rates. Some large mills have operated almost full, others ran at 50 to 75 per cent, while a number of small plants have been closed entirely. The divergences are due largely to the character of business the different mills commonly seek, as many small mills depend upon transient orders. This serves them in good stead on a rising market, as they obtain the advantage of price advances more promptly than the mills that book far ahead, but in times like these the policy is disadvantageous.

OPERATIONS IN DETAIL

On the whole, the sheet industry is probably operating at the best rate for any branch of the finished steel trade. The leading interest has been operating at about 80 per cent, while the independents have been doing about 70 per cent. In the case of tin plate there is the curious divergence that the leading interest has been operating at practically 100 per cent in the past fortnight, while the independents have not averaged more than about 50 per cent. The pipe mills show an average of 70 or 75 per cent, doing quite

well in the lap weld departments but rather poorly at butt weld furnaces. Wire mills are averaging 50 to 60 per cent, while plate mills are doing about the same and structural and rail mills are doing hardly anything.

The percentages of finishing capacity in operation as here estimated do not average nearly as high as the estimated percentage of steel production in proportion to steel making capacity, that being due to the simple fact that the finishing capacity of the industry materially exceeds the steel-making capacity, and this is a necessary alignment, otherwise the steel-making departments never could operate in full, as demand could not be expected to be distributed among the different finishing departments in the precise proportions required by their respective capacities.

No Investment Buying

The character of steel demand as shown by the proportions of various finished steel products lately called for is in strict conformity with what would be expected from a scrutiny of the industrial and economic situation. There is demand for steel that enters into common everyday use, while there is practically no demand for steel that enters into construction work. That is to be expected. The investment buyer has not acted. There are scarcely any building projects. The Bridge Builders' and Structural Society reports that the bookings of fabricated steel jobs in January represented 12 per cent of the month's capacity, this breaking the previous low record of 20 per cent, made in November, 1914.

Petroleum is not over-plentiful, the world's prospective requirements are heavy and new wells must continuously be brought in to maintain the country's production, hence it is not strange to find that in the tubular goods industry the most active branch is that of oil country goods. Standard steel pipe, particularly in butt weld sizes, is in very poor request, as it enters chiefly into building operations. A little business has been done in small lots of line pipe, and several large oil and gas interests have indicated to pipe mills that they are willing to go ahead with the laying of some large pipe lines, if they are permitted to buy at certain prices, these prices being only about 10 to 20 per cent below current quotations, so that here at any rate is a case of "the investor" naming his terms, and in substance actually making a bid. Generally speaking the investment buyer is not in the market and has not made up his mind as to the precise conditions he would require in order to bring him in.

The steel demand from the automobile trade is excellent, practically up to the highest level of the past. The automobile shops are not yet up to full production, but are rapidly being swung into line, and the makers are confident that before the end of the year they will be producing automobiles at a greater rate than ever before. They seem to be certain of their market and they are not particularly contentious as to prices to be paid for steel.

Prices to Decline

There is scarcely any doubt that finished steel prices will experience a very substantial decline by April 1. The reasoning is quite simple. Broadly speaking, there are two general classes of buying, that for current requirements and that for investment, or for construction work. The end of the war found it that the investment buyer was not ready to act and would hardly be ready until settled conditions throughout the world should become assured and prices of material and cost of labor should come down. There was no particular occasion, therefore, to consider the investment buyer in the matter of steel prices. He would not act even with a wholesale reduction. The current buyer might, however, be expected to buy in moderate fashion because he could not wait, and in keeping with this idea slight price reductions from the Government limits were made last December, averaging about $4 a ton on all products. It was thought at the time there might be another reduction of perhaps equal amount on April 1, in keeping with the quarterly consideration of prices practised by the War Industries Board during the period of control.

Developments of the past few weeks, however, have shown that even the transient or current buyer will not take hold to any extent at these prices. He has remarkable powers of staying out of the market, and he is greatly helped in this conduct by the fact that the mills can roll and ship material almost instantly on a new order. The need for maintaining stocks, on the part of the jobber and manufacturing consumer, is almost eliminated. In the late months of the war these buyers were complaining of inadequate stocks, in many cases, but the stocks were appraised according to the needs of the time, when mill deliveries were very uncertain.

Thus even the transient or everyday buyer has been failing the steel industry, and it is necessary to bring him in. Hopes have been entertained that there would be a spring buying movement of at least moderate proportions, but it appears that even that must be stimulated by price concessions. It is practically certain, therefore, that in the near future rather extensive reductions in steel prices will occur. While the steel trade is not permitted to meet and agree what it shall do, it has a spirit of following leadership, recognizing that it is necessary to have precise prices to which to adhere or utter market confusion would resu't. While the Steel Corporation frequently takes the lead, the prospect is that the prospective decline will be led by one of the independents, which will announce reduced prices, the other producers thereupon adopting these prices, whatever they may be. There are no definite predictions as to the size of the prospective declines. The lowest guess is that merchant steel bars will be put at 2c., from their present level of 2.70c., the Government limit having been 2.90c. That would make the reduction $14 per net ton, but it would leave bars at $12 a ton above the average of quotations in the ten-year pre-war period 1904 to 1913 inclusive. Billets in that event would probably strike around $35, with sheet bars perhaps $2 higher, and the merchant furnaces might find $25 a convenient price on which to make their fresh stand, basic being now $30 furnace, and foundry $31.

The Chemical Market

Coal-Tar Products:—While there has been no unusual volume of business noted for coal-tar products, little has developed in the way of price changes, in addition to the general list that has already been revised. Most all producers are anticipating a return to normal conditions in the trade, but, according to most reports, there is not much likelihood of any great resumption of business before the latter part of next month. Among the crude products, phenol maintains the unsettled position that has been in evidence during the recent period, while benzol is subject to a sufficient call to take the slack off the market. Some of the items are being offered in rather liberal quantities and most trading seems to be through first hands, who, for the most part, are not disposed to make any concessions to stimulate business, despite the fact that, in some instances, material is being offered through second hands somewhat below the manufacturers' prices.

Phenol:—Cheap offerings of this product seem to constitute the only activity and sales are noted as low as 8½c., drums included. In the aggregate, a large volume of business is evident, many manufacturers having discontinued the production, as quantities of the product are offered at prices considerably below the cost of manufacture.

Benzol:—Occasional lots of this commodity reach the resale market at prices ranging from 2c. to 3c. below the manufacturers' prices. However, the market is seemingly well maintained so far as prices are concerned and is generally regarded as steady.

Toluol:—Supplies of this material are none too freely offered by second hands, and when lots of the product are offered at prices below that of the producers, there is some interest generally noted on the part of buyers. Manufacturers are firmly maintaining their prices and report a fair volume of business passing.

Naphthaline:—The consumers of this product seem to be confining their attention along conservative buying, while in the resale market a fair volume of business is passing and this is generally transacted at price conces-

sions. First hands, however, have made no price changes for the various grades of this product.

Cresylic Acid:—Foreign competition has seemingly not affected the situation up to the present and prices for this product are subject to no material change. The current call is of no pronounced volume, although sufficient trading is passing to take the slack off the market.

Paraphenylenediamine:—This material is one of the coal-tar products that has maintained a steady position in the market, and while buying seems to be confined to small lots, a satisfactory business is generally noted. The various producers continue to quote on the former basis.

Dimethylaniline:—The sales for this material are of a minor character, and the recent decline in prices has seemingly had no effect in stimulating business. Buying is conducted along conservative lines, with stocks more than sufficient for the current call.

Dinitrophenol:—A satisfactory business is reported to be passing for this product, although in most directions there seems to be an accumulation of stocks, but prices remain unchanged at the recent decline.

Diphenylamine:—There has been some little trading in this comomidity at the recent decline in prices, but for the most part individual sales are of a minor character.

Beta Naphthol:—Local trading assumes a quiet attitude and there is an absence of anything like a normal demand; however, some factors have received inquiries for the product for export purposes and it is expected that consumption in this direction may bring about a more favorable condition. Quotations generally offered are continued on the former levels for the various grades.

Monochlorbenzol:—While there is the regular consuming trade in evidence, individual sales are in small lots and stocks are fully in accordance with the current call. Second hands are unable to offer material at concessions and manufacturers are firmly maintaining prices.

Paranitraniline:—The business passing in this commodity is of no unusual volume and the extent of the recent reduction in prices does not seem to be sufficient to be attractive to buyers. Stocks of the product in the various directions seem to be accumulating, which appears to be of some concern to producers.

HEAVY CHEMICALS:—The tone of the heavy chemical market continues to reflect a feeling of uncertainty with the majority of the consuming buyers, while on the other hand trading in many of the items under this heading has been somewhat more active, and now that the holidays are over, which undoubtedly has had its effect, most operators are looking forward to a more active market. Export trading, up to the present, has been in no pronounced volume, although the general outlook is quite favorable. While there has been no general decline in prices, trading among second hands was subject to keen competition, which resulted in concessions in some instances, but in the aggregate the volume of business was not of such proportions to effect any radical changes. Soda ash and caustic soda, the products of considerable interest, maintain a rather weak position in the market and both buyers and sellers are confining their attention along quiet lines.

Soda Ash:—While there has been an absence of important price fluctuations during the interval, trading was not sufficiently active to affect the situation one way or the other. Sales of bag ash from the warehouse were consumated at $1.40 per hundred lb., with barrel ash selling at $1.75 ex-store. Light ash in bags was generally offered at from $1.75 to $1.85, while movement in double bags was particularly quiet, and for this material at Middle Western shipping points prices range from $2.15 to $2.25. Dense ash in single bags was quoted at $3.25 to $3.30 ex-store in New York, while in Philadelphia, $3.60 was asked. Double bags at the same shipping point were held at $3.10, with 3c. the general quotation at Painsville.

Caustic Soda:—Quiet trading seems to have been the feature during the past two weeks, and at periods weak holders played havoc with the market and sales for ex-warehouse material were noted at $2.75. However, for the most part, prices were fairly well maintained despite the quiet conditions. It was rather difficult to do better than $2.85 per hundred lb. at the close for resale material, while others were holding at $2.95 and $3.05, but manufacturers displayed no disposition to make any effort to meet this situation.

Bleaching Powder:—The market for this commodity continues to be quiet, with local trading confined to small lots, and while purchasing for export purposes has been of no pronounced volume, a fairly active movement in this direction is noted. There were offerings at the close, by second hands, of large domestic drums at 1½c. per lb. works, while manufacturers were quoting 2c. Material in small export drums for immediate shipment from works was offered at 2⅝c. f.a.s. while the large drums were available at 2½c. f.a.s.

Copper Sulphate:—Despite the fact that manufacturers have lowered their prices for this commodity to $7.90 per hundred lb. there were offerings through second hands at $7.80 for the large crystals 99 per cent. Further reductions are not generally anticipated and business seems to be steady, but individual sales are for no important quantity and would indicate buying is conducted along conservative lines.

Cyanide of Soda:—The production of this chemical is confined to a few quarters and prices are firmly maintained, although business is of a routine nature, with the demand by no means pressing. The 96-98 per cent material is held at 30c. to 31c., while the chloride mixture of 73-76 per cent is quoted at 25c. to 27c. and the chloride carbonate mixture is offered at 20c. to 21c.

Sulphate of Alumina:—While supplies of this product are none too freely offered in the market, the consuming demand in proportion is not strong and no difficulty is experienced in meeting the situation. Prices are firmly maintained in most directions, with the iron free being held at from 3¼c. to 3½c. per lb., while the commercial grade is quoted at 2½c. to 2⅝c. ex-store.

Bicarbonate of Soda:—The commodity is easier and there have been some fractional declines in prices. For instance, there were resale offerings of barrel material at $2.65 per hundred lb., but manufacturers are not inclined to shade their recent quotations of $2.75.

Silicate of Soda:—A fair volume of business is noted to be passing for this material, but factors of the product report stocks in sufficient quantity to take care of additional business. The 40-degree variety seems to be somewhat easy in supply and was offered at from 2¼c. to 2⅜c. per lb. ex-warehouse, while the 60-degree product seems to be more scarce and is quoted at 4⅜c. to 5c. ex-store.

Sodium Sulphide:—Local trading continues along quiet lines, while some business is passing for export purposes and prices are steady. The 60 per cent fused variety is held at 4¾c. to 5c. ex-store, while the 30-32 per cent crystals are quoted at 2⅝c. to 3c. per lb.

Bichromate of Soda:—No material improvement can be traced in this market; sales during the past week were noted as low as 12¼c. This, however, is not generally regarded a market figure with quotations at the close ranging from 12½c. to 13c.

Bichromate of Potash:—The demand for this product has been of sufficient volume to keep the spot situation well sold up and the market is in such a condition at the moment that it is rather difficult to locate spot material. The various operators are quoting 37½c. to 38½c. for material to be delivered in about ten days.

Hyposulphite of Soda:—The pea crystal product, which is the most preferable, is seemingly none too free in supply, although the spot situation, at most times, is fully in proportion to the current call. Prices are firm at from 3¼c. to 3⅜c. per lb. ex-store.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET FEB. 21, 1919

Acetic anhydride	lb.	.90 —	1.00
Acetone	lb.	.15½ —	.16
Acid, acetic, 28 per cent	cwt.	3.25 —	3.50
Acetic, 56 per cent	cwt.	6.50 —	6.75
Acetic, glacial, 99½ per cent, carboys	cwt.	14.00 —	14.50
Boric, crystals	lb.	.13½ —	.15
Citric, crystals	lb.	1.25 —	1.27
Hydrochloric, (22°)	cwt.	2.50 —	3.00
Hydrofluoric, 30 per cent, in barrels	lb.	.08 —	.08½
Lactic, 44 per cent	lb.	.14 —	.15
Lactic, 22 per cent	lb.	.06 —	.07
Molybdic, C. P	lb.	6.90 —	7.40
Nitric, 36 deg	lb.	.07 —	.....
Nitric, 42 deg	lb.	.08½ —	.10
Oxalic, crystals	lb.	.36 —	.38
Phosphoric, 47-50 per cent paste	lb.	.07½ —	.10
Phosphoric, ref. 50 per cent	lb.	.35 —	.40
Picric	lb.	.75 —	.85
Pyrogallic, resublimed	lb.	2.90 —	3.20
Sulphuric, 60 deg works	ton	14.00 —	16.00
Sulphuric, 66 deg works, tank cars	ton	23.00 —	24.00
Sulphuric, oleum (Fuming), tank cars	ton	25.00 —	26.00
Tannic, U. S. P., bulk	lb.	1.40 —	1.50
Tartaric, crystals	lb.	.84½ —	.85
Tungstic, per lb. of W	lb.	1.70 —	1.75
Alcohol, sugar cane, 188 proof	gal.	4.85 —	.....
Alcohol, wood, 95 per cent	gal.	1.22 —	1.24
Alcohol, denatured, 180 proof	gal.	.50 —	.52
Alum, ammonia lump	lb.	.04 —	.05
Alum, chrome ammonium	lb.	.17½ —	.18
Alum, chrome potassium	lb.	.20 —	.22
Alum, chrome sodium	lb.	.12½ —	.13
Alum, potash lump	lb.	.09½ —	.10
Aluminium sulphate, technical	lb.	.02½ —	.02½
Aluminium sulphate, iron free	lb.	.03½ —	.03½
Ammonia aqua, 26 deg., carboys	lb.	.07 —	.08½
Ammonia, anhydrous	lb.	.30 —	.35
Ammonium carbonate	lb.	.13 —	.14
Ammonium nitrate	lb.	.16 —	.17
Ammonium, sulphate domestic	lb.	.05½ —	.05½
Amyl acetate	gal.	3.75 —	4.25
Arsenic, white	lb.	.09½ —	.10
Arsenic, red	lb.	.65 —	.70
Barium carbonate, 99 per cent	ton	80.00 —	90.00
Barium carbonate, 97-98 per cent	ton	65.00 —	67.00
Barium chloride	ton	65.00 —	75.00
Barium sulphate (Blanc Fixe, Dry)	lb.	.03½ —	.04
Barium nitrate	lb.	.10 —	.11
Barium peroxide, basis 70 per cent	lb.	.30 —	.32
Bleaching powder, 35 per cent chlorine	lb.	.01½ —	.02½
Borax, crystals, sacks	lb.	.08½ —	.08½
Brimstone, crude	ton	65.00 —	70.00
Bromine, technical	lb.	.65 —	.....
Calcium, acetate, crude	lb.	.04 —	.05
Calcium, carbide	lb.	.08 —	.10
Calcium chloride, 7-75 per cent, fused, lump	ton	22.00 —	24.00
Calcium peroxide	lb.	1.50 —	1.70
Calcium phosphate	lb.	.22 —	.23
Calcium sulphate, 98-99 per cent	lb.	.09 —	.09½
Carbon bisulphide	lb.	.07 —	.08
Carbon tetrachloride, drums	lb.	.15 —	.16
Carbonyl chloride (phosgene)	lb.	.75 —	1.00
Caustic potash, 88-92 per cent	lb.	.55 —	.65
Caustic soda, 76 per cent	100 lb.	2.85 —	2.95
Chlorine, liquid	lb.	.10 —	.12
Cobalt oxide	lb.	1.60 —	1.65
Copperas	lb.	.01½ —	.02½
Copper carbonate	lb.	.30 —	.31
Copper cyanide	lb.	.75 —	.78
Copper sulphate, 99 per cent, large crystals	lb.	.07½ —	.08
Cream of tartar, crystals	lb.	.58 —	.60
Epsom salt, bags, U.S.P	100 lb.	2.75 —	.....
Formaldehyde, 40 per cent	lb.	.22½ —	.23
Glauber's salt	lb.	.02 —	.02½
Glycerine, bulk, C.P	lb.	.20 —	.21
Iodine, resublimed	lb.	4.25 —	4.30
Iron oxide	lb.	.06 —	.08
Lead acetate, white crystal	lb.	.14 —	.15
Lead arsenate (Paste)	lb.	.15 —	.18
Lead nitrate, C. P	lb.	.85 —	.86
Litharge, American	lb.	.11 —	.12
Lithium, carbonate	lb.	1.50 —	2.05
Magnesium carbonate, technical	lb.	.16 —	.17
Nickel salt, single	lb.	.14 —	.15
Nickel salt, double	lb.	.12 —	.13
Phosgene (see Carbonyl chloride)	lb.	.75 —	1.00
Phosphorus, red	lb.	.75 —	.80
Phosphorus, yellow	lb.	.50 —	.60
Potassium bichromate	lb.	.38 —	.40
Potassium bromide granular	lb.	1.25 —	1.26
Potassium carbonate calcined, 85-90 per cent	lb.	.38 —	.40
Potassium chlorate, crystals	lb.	.40 —	.41
Potassium cyanide, 98-99 per cent	lb.	.60 —	.70
Potassium iodide	lb.	3.75 —	3.80
Potassium muriate, 80-85 p. c. basis of 80 p. c	ton	270.00 —	285.00
Potassium nitrate	lb.	.27 —	.31
Potassium permanganate, U. S. P	lb.	1.00 —	1.05
Potassium prussiate, red	lb.	1.60 —	1.75
Potassium prussiate, yellow	lb.	.58 —	.60
Potassium sulphate, 90-95 p. c. basis 90 p.c	ton	Nominal	
Rochelle salts	lb.	.46½ —	.48
Salammoniac, gray gran	lb.	.16 —	.18
Salammoniac, white gran	lb.	.14 —	.16
Sal soda	100 lb.	1.75 —	2.00
Salt cake	ton	18.00 —	20.00
Silver cyanide, based on market price of silver	oz.	.....	.....
Silver nitrate	oz.	.63½ —	.64
Soda ash, 58 per cent, light, flat (bags)	100 lb.	1.45 —	1.50
Soda ash, 58 per cent, dense, flat	100 lb.	3.25 —	3.35
Sodium acetate	lb.	.12 —	.13
Sodium bicarbonate, domestic	lb.	.02½ —	.02½
Sodium bicarbonate, English	lb.	.....	.....
Sodium bichromate	lb.	.14½ —	.15½
Sodium bisulphite, powd	lb.	.12 —	.14
Sodium chlorate	lb.	.18 —	.19
Sodium cyanide	lb.	.30 —	.35
Sodium fluoride, commercial	lb.	.16 —	.17
Sodium hyposulphite	100 lb.	3.25 —	3.75
Sodium molybdate, per lb. of Mo	lb.	2.50 —	.....
Sodium nitrate, 95 per cent	100 lb.	4.42 —	4.55
Sodium nitrite	lb.	.14 —	.16
Sodium peroxide	lb.	.35 —	.45
Sodium phosphate	lb.	.04 —	.04½
Sodium prussiate, yellow	lb.	.26 —	.28
Sodium silicate, liquid (60 deg.)	lb.	.04½ —	.05
Sodium sulphide, 30 per cent, crystals	lb.	.02½ —	.02½
Sodium sulphide, 60 per cent, fused	lb.	.04½ —	.05
Sodium sulphite	lb.	.05½ —	.06
Strontium nitrate	lb.	.25 —	.30
Sulphur chloride, drums	lb.	.07½ —	.09
Sulphur dioxide, liquid, in cylinders	lb.	.15 —	.40
Sulphur, flowers, sublimed	100 lb.	4.35 —	4.50
Sulphur, roll	100 lb.	3.70 —	3.85
Sulphur, crude	ton	35.00 —	.....
Tin bichloride, 50 deg	lb.	.28 —	.29
Tin oxide	lb.	.70 —	.80
Zinc carbonate	lb.	.18 —	.20
Zinc chloride	lb.	.14 —	.14½
Zinc cyanide	lb.	Nominal	
Zinc dust, 350 mesh	lb.	.13½ —	.14
Zinc oxide, American process, works	lb.	.10 —	.12
Zinc sulphate	lb.	.04½ —	.06½

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.22 —	.27
Benzol, 90 per cent	gal.	.25 —	.....
Toluol, in tank cars	gal.	.25 —	.....
Toluol, in drums	gal.	.30 —	.35
Xylol, pure, water white	gal.	.45 —	.55
Solvent naphtha, water white	gal.	.20 —	.25
Solvent naphtha, crude, heavy	gal.	.15 —	.17
Creosote oil, 25 per cent	gal.	.45 —	.55
Dip oil, 20 per cent	gal.	.35 —	.40
Pitch, various grades	ton	8.00 —	20.00
Carbolic acid, crude, 95-97 per cent	lb.	Nominal	
Carbolic acid, crude, 50 per cent	lb.	Nominal	
Carbolic acid, crude, 25 per cent	lb.	Nominal	
Cresol, U. S. P	lb.	.18 —	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00 —	1.10
Alpha naphthol, refined	lb.	1.50 —	1.60
Alpha naphthylamine	lb.	.48 —	.50
Aniline oil, drums extra	lb.	.25 —	.27
Aniline salts	lb.	.36 —	.40
Anthracene, 80 per cent	lb.	.50 —	.55
Benzaldehyde (f.f.c.)	lb.	4.25 —	4.50
Benzidine, base	lb.	1.40 —	1.45
Benzidine, sulphate	lb.	1.15 —	1.25
Benzoic acid, U. S. P	lb.	1.60 —	1.65
Benzoate of soda, U. S. P	lb.	1.50 —	1.60
Benzyl chloride	lb.	.50 —	.....
Beta naphthol benzoate	lb.	5.50 —	6.00
Beta naphthol, sublimed	lb.	.75 —	.85
Beta naphthylamine, sublimed	lb.	2.60 —	2.65
Dichlorbenzol	lb.	.15 —	.20
Diethylaniline	lb.	3.25 —	4.00
Dinitrobenzol	lb.	.36 —	.38
Dinitrochlorbenzol	lb.	.30 —	.35
Dinitronaphthaline	lb.	.55 —	.60
Dinitrotoluol	lb.	.40 —	.50
Dinitrophenol	lb.	.39 —	.45
Dimethylaniline	lb.	.57 —	.65
Diphenylamine	lb.	.75 —	.85
H-acid	lb.	2.35 —	2.75
Metaphenylenediamine	lb.	1.55 —	1.75
Monochlorbenzol	lb.	.16 —	.19
Naphthalene, flake	lb.	.08 —	.09
Naphthalene, balls	lb.	.11½ —	.12½
Naphtionic acid, crude	lb.	1.20 —	1.30
Naphthylamin-di-sulphonic acid	lb.	1.00 —	1.10
Nitro naphthaline	lb.	.45 —	.50
Nitro toluol	lb.	.55 —	.60
Ortho-amidophenol	lb.	6.00 —	7.00
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-toluidine	lb.	.50 —	.90
Ortho-nitro-toluol	lb.	.75 —	.85
Para-amidophenol, base	lb.	3.25 —	3.65
Para-amidophenol, H. C. L	lb.	3.75 —	4.25
Para-dichlor-benzol	lb.	.15 —	.20
Paranitraniline	lb.	1.35 —	1.45
Para-nitro-toluol	lb.	1.50 —	1.60
Paraphenylenediamine	lb.	3.25 —	3.50
Para toluidine	lb.	1.85 —	1.95
Phthalic acid anhydride	lb.	3.25 —	3.50
Phenol, U. S. P	lb.	Nominal	
Resorcin, technical	lb.	4.50 —	5.00
Resorcin, pure	lb.	7.00 —	8.00
Salicylic acid, U. S. P	lb.	.55 —	.....
Salol	lb.	1.10 —	1.15
Sulphanilic acid, crude	lb.	.25 —	.31
Toluidine	lb.	2.45 —	.....
Toluidine-mixture	lb.	.80 —	1.00

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	4.00 —	.....
Corning, Ohio	bbl.	2.85 —	.....
Somerset, Ky	bbl.	2.60 —	.....
Wooster, Ohio	bbl.	2.58 —	.....
Indiana	bbl.	2.28 —	.....
Illinois	bbl.	2.25 —	.....
Oklahoma and Kansas	bbl.	2.25 —	.....
Caddo, La., light	bbl.	2.10 —	2.25
Corsicana, Tex., light	bbl.	2.25 —	.....
California	bbl.	1.24 —	1.57
Gulf Coast	bbl.	1.25 —	.....
Mexican	bbl.	1.90 —	.....
Fuel Oil			
New York	gal.	.15 —	.....
Philadelphia	gal.	.10½ —	.....
Baltimore	gal.	.07½ —	.15
Pittsburgh	gal.	.07½ —	.10½
Texas	bbl.	1.85 —	2.35
Los Angeles	bbl.	1.65 —	.....

Gasoline (Wholesale)

New York, motor	gal.	.24½	—	.....
Gas machine	gal.	.41½	—	.....
72-76 degrees	gal.	.33½	—	.39½
70-72 degrees	gal.	.32	—	.37½
67-70 degrees	gal.	.30½	—	.36½
Pittsburgh, motor	gal.	.25½	—	.....
Chicago, motor	gal.	.21	—	.....
Oklahoma, motor	gal.	.23½	—	.....
San Francisco, motor	gal.	.20½	—	.....

Paraffine Waxes

Crude, 103 to 105 deg. m.pt.	lb.	.08½	—	.09
Crude, 118 to 120 deg. m.pt.	lb.	.09½	—	.10
Crude, 124 to 126 deg. m.pt.	lb.	.10	—	.....
Refined, 120 deg. m.pt.	lb.	.13½	—	.....
Refined, 128 deg. m.pt.	lb.	.14	—	.....
Refined, 135 deg. m.pt.	lb.	.16	—	.16½
Ozokerite, brown	lb.	.75	—	.80
Ozokerite, green	lb.	.85	—	.90

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.23	—	.24
Cylinder, light	gal.	.42	—	.44
Cylinder, dark	gal.	.39	—	.43
Paraffine, high viscosity	gal.	.40	—	.41
Paraffine, 0.903 sp. gr.	gal.	.33	—	.34
Paraffine, 0.885 sp. gr.	gal.	.26	—	.28

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f. o. b. Florida	gal.	.44	—	.....
Pine oil, steam-distilled, sp. gr. 0.925-0.940	gal.	.58	—	.60
Pine oil, destructively distilled	gal.	.58	—	.60
Pine-tar oil, sp. gr. 1.02-1.035	gal.	.35	—	.....
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal	.42	—	.....
Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.37	—	.....
Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.28	—	.....
Pine-tar oil, ref., thin, sp. gr. 1.060-1.080	gal.	.32	—	.....
Turpentine, crude, sp. gr. 0.870-0.900	gal.	.45	—	.....
Hardwood oil, f.o.b. Michigan, sp.gr. 0.960-0.990	gal.	.23	—	.....
Hardwood oil, f.o.b. Michigan, sp.gr. 1.06-1.08	gal.	.23	—	.....
Wood creosote, ref., f.o.b. Florida	gal.	.31	—	.....

Naval Stores

Rosin A-E barrel	280 lb.	13.10	—	13.20
Rosin F-I	280 lb.	13.20	—	13.50
Rosin K-N	280 lb.	15.50	—	16.65
Rosin WG-W	280 lb.	16.75	—	17.10
Spirits of turpentine	gal.	.70	—	.....
Wood turpentine, steam distilled	gal.	.64	—	.65
Wood turnpentine, destructively distilled	gal.	.63	—	.65½
Pitch	bbl. 200 lb.	8.00	—	
Tar, kiln dried	280 lb.	13.00	—	13.50
Retort tar	280 lb.	14.00	—	14.50
Rosin oil, first run	gal.	.74	—	.....
Second run	gal.	.76	—	.....
Third run	gal.	.72	—	.....
Fourth run	gal.	.92	—	.....

Vegetable Oils

Castor oil	lb.	.21	—	.29
China wood oil	lb.	.23	—	.24
Cocoanut oil	lb.	.14	—	.19
Corn oil	lb.	.13	—	.17
Cottonseed oil, crude	lb.	.17½	—	.22
Linseed oil, raw, cars	gal.	1.45	—	1.48
Palm	lb.	.18	—	.21½
Peanut oil, crude	lb.	.14½	—	.21
Soya bean oil, Manchuria	lb.	.12½	—	.15

Glues

Extra white	lb.	.31	—	.35
Cabinet	lb.	.25	—	.26
Brown foot stock	lb.	.15	—	.19
Fish glue, 50-gal. barrels	gal.	1.00	—	1.50

Miscellaneous Materials

Barytes, floated, white, domestic	ton	33.00	—	36.00
Beeswax, white, pure	lb.	.63	—	.65
Beeswax, unbleached	lb.	.43	—	.48
Blanc fixe	lb.	.05½	—	.....
Casein	lb.	.17½	—	.30
Chalk, light, precipitated, English	lb.	.04½	—	.06
China clay, imported, lump	ton	20.00	—	40.00
China clay, domestic, lump	ton	15.00	—	22.50
Feldspar	ton	8.00	—	12.00
Fluorspar, gravel, f. o. b. mines	ton	28.00	—	40.00
Fluorspar, washed, powdered	ton	90.00	—	
Fuller's earth, powdered	100 lb.	1.50	—	2.00
Graphite Alabama	lb.	.08	—	.12
Ceylon	lb.	.09	—	.22
Madagascar	lb.	.10	—	.15
Mexican	ton	35.00	—	75.00
Japan wax	lb.	.18	—	.19
Orange shellac	lb.	.72	—	.80
Pumice stone	lb.	.04	—	.08
Soapstone	ton	15.00	—	25.00
Stearic acid	lb.	.20½	—	.22½
Talc, American, white	ton	20.00	—	40.00

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	100.00	—	120.00
Chrome cement	net ton	75.00	—	.....
Clay brick, first quality fireclay	per 1000	40.00	—	50.00
Clay brick, second quality	per 1000	35.00	—	40.00
Magnesite, raw	ton	30.00	—	35.00
Magnesite, calcined, powdered	ton	50.00	—	65.00
Magnesite, dead burned	net ton	38.00	—	40.00
Magnesia brick, 9x4½x2½	net ton	110.00	—	125.00
Silica brick	per 1000	45.00	—	55.00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y.	ton	200.00	—	250.00
Ferrocerium	lb.	15.00	—	30.00
Ferrochromium, per lb. of Cr	lb.	.30	—	.40
Ferromanganese, domestic, 70 per cent basis	ton	150.00	—	200.00
Spielgeleisen (16-18%)	ton	57.00	—	58.00
Ferromolybdenum, per lb. of Mo	lb.	3.50	—	4.50
Ferrosilicon, 50 per cent, contract	ton	120.00	—	125.00
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	Nominal		
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.50	—	.....
Ferrovanadium, f.o.b. works	lb.	....	—	.....

Ores and Semi-finished Products

Chrome ore, 45 per cent minimum, f.o.b. Cal. per unit	ton	1.50	—	1.55
Coke	ton	6.00	—	7.00
Petroleum Coke	ton	16.00	—	.....
Manganese ore, 48 per cent and over, per unit	ton	1.20	—	.....
Manganese ore, chemical	ton	80.00	—	100.00
Molybdenite, per lb. of MoS_2	lb.	.80	—	.85
Tungsten, Scheelite, per unit of WO_3	ton	17.00	—	24.00
Tungsten, Wolframite, per unit of WO_3	ton	15.00	—	21.00
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium pentoxide, 99%	lb.	10.50	—	.....
Pyrites, foreign	unit	.17	—	.....
Pyrites, domestic	unit	.28	—	.30½

Plant Supplies

BUILDING MATERIALS

Common clay bricks	M	14.00	—	15.00
Faced Brick	M	37.00	—	46.00
Hollow tile, 4x12x12	M	60.00	—	.....
Hollow tile, 12x12x12	M	170.00	—	.....
Lime	ton	16.50	—	.....
Portland cement	bbl.	2.59	—	.....
Single glass (82-lb.), 10x26-16x24		21.00	—	27.00
Double glass (164 lb.), 10x26-16x29		31.00	—	39.00
Yellow pine lumber	M	39.00	—	45.00
Cypress	M	70.00	—	.....
Tarred felt (14-lb. sq.)	ton	61.00	—	.....
Roofing pitch	ton	27.00	—	.....
Asphalt coated roofing (35-55-lb.sq.)	sq.	1.60	—	2.45
Slate surfaced asphalt shingles	sq.	5.25	—	5.50
Corrugated galvanized iron	ton	109.00	—	127.00
Putty	100 lb.	6.25	—	.....
Red oxide (Ppte. Copperas)	100 lb.	15.00	—	20.00
Native red oxide	100 lb.	3.25	—	8.00
Red metallic paint	100 lb.	1.20	—	1.50
White lead in oil	100 lb.	15.00	—	16.00
White lead (dry.)	100 lb.	11.00	—	13.00
Red lead in oil	100 lb.	12.28	—	14.50
Red lead (dry)	100 lb.	14.50	—	.....
Zinc oxide (dry)	100 lb.	13.00	—	14.50
Zinc oxide—leaded	100 lb.	9.00	—	10.00
Yellow ochre	100 lb.	1.50	—	10.00
Ultra marine blue	100 lb.	14.00	—	50.00
Prussian blue	100 lb.	135.00	—	150.00
Chrome green	100 lb.	40.00	—	70.00
Paris green	100 lb.	43.00	—	49.00
Mineral black	100 lb.	1.75	—	2.25
Powdered bone black	100 lb.	5.50	—	12.00
Lampblack	100 lb.	15.00	—	45.00
Gas carbon	100 lb.	16.00	—	25.00
Mexican petroleum pitch	100 lb.	1.00	—	2.00
Gilsonite	100 lb.	2.00	—	2.50
Coal tar pitch	100 lb.	.60	—	1.25

STRUCTURAL IRON

Blue annealed sheet iron	ton	77.00	—	82.00
Black sheet iron	ton	90.00	—	96.00
Galvanized iron	ton	101.00	—	131.00
Tern plate, 8-lb. coating	ton	145.00	—	148.00
Tern plate, 15-lb. coating	ton	175.00	—	.....
Tern plate, 25-lb. coating	ton	200.00	—	.....
Tern plate, 40-lb. coating	ton	230.00	—	.....
Tin plate, prime	ton	147.00	—	155.00
Tank plates	ton	60.00	—	65.00
Beams, channels, angles, T's, Z's	ton	56.00	—	60.00
Rivets	ton	88.00	—	92.00
Steel pipe, ⅜ to 3-inch	ton	51.00	—	.....
Bar iron and steel	ton	60.00	—	70.00
Chain (1 inch proof coil)	ton	150.00	—	.....
Nails, bolts, nuts, washers	ton	70.00	—	80.00
Tool steel, special alloys	ton	300.00	—	500.00
Bessemer pig iron	ton	32.00	—	35.20
Bessemer steel	ton	43.50	—	47.50
No. 2 foundry	ton	37.90	—	.....
Steel billets (4 x 4)	ton	47.50	—	.....

POWER HOUSE SUPPLIES

Steam packing, rubber duck	lb.	.99	—	1.10
Asbestos, high pressure	lb.	1.76	—	.....
Asbestos, wired	lb.	1.30	—	.....
Asbestos, graphited braid	lb.	1.21	—	.....
Asbestos, wick	lb.	.75	—	.....
Rubber, sheet	lb.	.66	—	.....
Cup grease	lb.	.07	—	.....
Transmission grease	lb.	.07	—	.....
Axle grease	lb.	.04½	—	.....
Gear grease	lb.	.04½	—	.....
Cotton waste	lb.	.08½	—	.11
Hose, underwriters, 2½ in.	ft.	.75	—	.....
Hose, air, ¾ in.	ft.	.50	—	.60

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Arizona

AGUILA—The Bullard Mining Co., Wickenburg, will build a new leaching plant at its properties here.

BOUSE—The Arizona Desert Mining & Milling Co., Bisbee, will install two ball-mill units supplementing 20-ton mill now on ground and operated. J. H. King, superintendent.

Colorado

EUREKA—The Empire State Mines & Reduction Co., will build a 50-ton unit of the 100-ton concentrating mill near here, and is in the market for lumber, crushers, rolls, classifiers, concentrating tables, pulleys, belting, motors, roofing, pipe, etc. Estimated cost, $25,000. W. Akers, superintendent.

Connecticut

HARTFORD—The city will build a slow sand filtration plant, consisting of eight half-acre filter beds and a 40 x 40 ft. laboratory building. Address Chief Engineer, Hartford Water Works, Room 702, Pilgard Building.

Georgia

SAVANNAH—The Southern Fertilizer & Chemical Co., American Bank & Trade Building, will rebuild its plant, recently destroyed by fire, entailing a loss of $225,000.

Idaho

BONNERS FERRY—The Cyanide Gold Mining Co., recently incorporated with a capital of $3,000,000, has taken over the property of the Deer Creek Gold Mining Co., near here and will develop same. Plans include the construction of a large cyanide plant.

CALDWELL—The School District is having plans prepared by Wayland & Fennell, architects, Idaho Bldg., Boise, for the construction of a two-story, concrete high school building. Plans include the installation of a chemical laboratory and scientific rooms. Total estimated cost, $75,000.

NAMPA—The city will build a 700,000-gal. disposal plant in connection with the new sewerage system. L. R. Cook, City Hall, engineer.

PINE CREEK—The Nabob Consolidated Mining Co., Kellogg, will build a new concentrating plant at the works here. Estimated cost, $50,000. H. C. Barnett, Kellogg, manager.

Illinois

EAST ST. LOUIS—The Obear-Nestor Glass Co., Broadway and Belt Line R.R., has awarded the contract for the construction of a two-story, 82 x 192 ft. glass factory, to Keeley Bros., Belt and State Sts. Estimated cost, $65,000.

ROCK PARK—The Rock Falls Box Board Co. will build a three-story, 120 x 135-ft. factory and is in the market for equipment for same. Total estimated cost, $130,000. J. L. Carey, 208 North Laramie Ave., Chicago, engineer.

Kentucky

OWENSBORO—The Glenmore Distilleries Co. will build a distillery for the manufacture of alcohol.

Maryland

BALTIMORE—The Liberty Yeast Corporation, incorporated by J. Bannister Hall, 609 Calvert Building, and associates, with $3,000,000 capital, has acquired the Monumental Distillery at 11th and O'Donnell Sts. and will remodel and equip same for the manufacture of yeast and its by-products.

CANTON (Baltimore P. O.)—J. M. Jones, 1621 Park Ave., Baltimore, and associates, have acquired a site on 5th Ave., and will build a tin manufacturing plant. Estimated cost, $500,000.

HYATTSVILLE—The Washington Suburban Sanitary District is having plans prepared by R. B. Morse, engineer, 324 North Charles St., Baltimore, for impounding the waters of Patuxent, Little Patuxent and Middle Patuxent Rivers to develop water supply. Project includes the construction of a rapid sand filtration plant, etc. Estimated cost, $2,500,000.

Michigan

DETROIT—The Board of Education will develop the laboratory in the Central High School building, Cass and Warren Aves., cost $47,160; equipment for same, $2500; filtering and sterilizing equipment for swimming pool in Cass Technical High School, $70,700.

DETROIT—The Water Board has recommended the City Council to build a complete filtration plant. Estimated cost, $5,326,000. G. H. Fenkell, chief engineer.

HOLLAND—The DePree Chemical Co., 133 West Washington St., Chicago, Ill., will build a chemical plant here.

PONTIAC—The City Clerk will receive bids until June 1 for the construction of a sewage disposal plant, including Imhoff tanks and trickling filters. Estimated cost, $300,000. H. H. Barnett, City Hall, engineer. Noted Feb. 1.

RIVER ROUGE—The Semet-Solvey Co., Milton Ave., Syracuse, N. Y., will build a 50 x 150 ft. acid washing machine house here.

Missouri

CARROLLTON—The Water, Light & Transit Co. will install a modern water filtering system and make other improvements to its property. S. J. Jones, Carroll Exchange Bank Bldg., president.

JOPLIN—The Texas Mining & Milling Co. will install a complete 150-ton mill and is in the market for a hoisting engine, blower engine and derrick boiler. Estimated cost, $25,000. E. D. James, manager.

Minnesota

WASHINGTON—The Directors of the Southwestern Minnesota Sanitarium have awarded the contract for installing a filter plant here, to W. Danforth, Germania Life Building, St. Paul. Estimated cost, $13,660.

Montana

NEIHART—The Cascade Silver Mines & Mills will install a concentrator and trams and is in the market for machinery necessary for the repair and upkeep of same. Estimated cost, $300,000.

Nebraska

OMAHA—The State Legislature plans to appropriate $40,000 for electrical apparatus, laboratory equipment, etc. J. Latenser & Sons, 632 Bee Building, architect.

New Jersey

CAMDEN—J. Evanson & Son, Delaware Ave. and Pennsylvania R.R., will rebuild its soap factory, recently destroyed by fire, and is in the market for machinery for same, including drying and molding machinery, belts, conveyors, heating bags, dry kilns etc. Estimated cost, $150,000.

ELIZABETH—The United States Leather Co., 856 Magnolia St., has awarded the contract for the construction of a two-story, 115 x 220 ft. factory, to the Turner Construction Co., 244 Madison Ave., New York City. Estimated cost, $200,000.

KEARNY—Swift & Co., 32 10th Ave., New York City, N. Y., will rebuild its fertilizer works, boiler plant, etc., here, recently destroyed by fire, entailing a loss of $150,000.

NEWARK—Eimer & Amend, 13-17 Margaretta St., has awarded the contract for the construction of an addition to its chemical plant, to Anthony Imhoff, Inc., 248 West 18th St., New York City. Estimated cost, $3500.

NEWARK—Kelly & McLaughlin, 93 Colder St., will build an addition to its plant for the manufacture of leather. Estimated cost, $8000. A. Peter, 828 Broad St., architect.

New York

NEW YORK—The Commissioner of Water Supply, Gas & Electricity, Municipal Bldg., has awarded the contract for furnishing and delivering liquid chlorine, to the Hooker Electrochemical Co., 40 Wall St., $7955; chloride of lime, to Arnold Hoffman, Providence, R. I., $1094, respectively. Noted Feb. 15.

POUGHKEEPSIE—The State Hospital Commission, Capitol, Albany, received bids Feb. 11 for building intake crib in the Hudson River, thence to filters, installing new filters, also changing water mains and reservoir at the Hudson River State Hospital, here, from C. R. Simpson, 90 West St., New York City, $57,887; H. E. Fox Construction Co., 81 East 125th St., New York City, $58,000; New York Sewage Disposal Co., 37 East 28th St., New York City, $62,997. Noted Feb. 1.

Ohio

IRONVILLE—The Paragon Refining Co., 2935 Front St., Toledo, will build a refining plant here. Estimated cost, $100,000.

Oklahoma

MIAMI—The Alexander Lead & Zinc Co. will build a mill and develop property here. Estimated cost, $75,000. G. M. Ramsey, superintendent.

Oregon

ASTORIA—The Astoria Pulp & Paper Co. will build a paper mill on 11th St. and Taylor Rd. Estimated cost, $250,000.

Pennsylvania

BLAIRSVILLE—S. S. Richard, Altoona, will build a hospital and group of institutional buildings near here, consisting of sewage disposal plant, reservoir, administration building, etc. F. McCrooks, Jones Law Building, Pittsburgh, architect.

PHILADELPHIA—N. Drassner, 1909 South 6th St., will build a two-story, 48 x 116 ft. chemical factory at 612-616 Moore St. Estimated cost, $20,000. H. H. Kline, 536 Mifflin St., engineer.

South Dakota

ABERDEEN—Dr. R. L. Mudry will receive bids until March 18 for the construction of a chemical building here. J. W. Henry, architect.

Texas

NORTH FORT WORTH—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will receive bids until March 10 for the construction of an argon production plant here, to consist of an office and laboratory building, lime storage shed, compression building, separation building, pressure reducer house, nitrogen cylinder house, carbon dioxide removal system and lime mixing shed. Estimated cost, $607,250.

FORT WORTH—The Evans Thwing Refining Co. has awarded the contract for the construction of an oil refinery, to the Reeves Bros., Alliance. Noted Dec. 30.

McKINNEY—The Texas Cotton Mills Co. will build an indigo-dye plant. Estimated cost, $60,000.

SAN ANGELO—The city will install a filtration plant. Estimated cost, $30,000. R. H. Henderson, mayor.

YOAKUM—The Texas Hide & Leather Co., recently organized, will build a factory for the manufacture of coarse grades of leather. A. Hofheinz, manager.

Virginia

ORANGE—The West Virginia Timber Co., 510 Charleston National Bank Building, Charleston, W. Va., will build an acid and byproducts plant and saw mill here. Estimated cost, $500,000. G. E. Breece, president.

ROANOKE—The United States Potash & Brick Corp., recently incorporated with $1,000,000 capital, will build a plant to have a daily capacity of 25 tons of caustic potash. O. T. Dennhardt, Box 956, manager.

Washington

TURNER—The Loon Lake Copper Mining Co., 408 Columbia Bldg., Spokane, will build a concentrating mill to have a daily capacity of 100 tons. J. McCormick, president.

West Virginia

CLARKSBURG — The Clarksburg Water Board will build a one-story, 20 x 25 ft. filtration plant and install filter equipment and piping.

Alberta

EDMONTON—The City Council will build an addition to the filtration plant. Estimated cost, $30,000. C. E. K. Fox, clk.

British Columbia

KIMBERLY—The Consolidated Mining & Smelting Co. will build extensive additions and improvements to the concentration plant to treat the increased tonnage of the Sullivan mine here.

PORT MOODY—The Moody Rolling Mills, Ltd., Pacific Building, Vancouver, will build a steel rolling mill here.

VANCOUVER — The Bowena Copper Mines, Ltd., 419 Rogers Bldg., will build a concentrating mill. C. M. Oliver, secretary.

VICTORIA — The Tudhope Electric Metals, Ltd., will build a smelting plant. Estimated cost, $8700.

Ontario

CONISTON—The Mond Nickel Co. will establish three new furnaces, thereby doubling the capacity of its plant. C. V. Corliss, manager.

HAMILTON—The Dominion Foundries & Steel Co., Ltd., is receiving bids for the construction of a new plate mill having a capacity of 12,000 tons per month. Noted Feb. 1.

NORWAY—The city will build a sewage disposal plant. Address J. Brown.

OTTAWA—The Board of Control will soon award the contract for furnishing 30,000 lb. of liquid chlorine. A. F. MacCallum, engineer.

OTTAWA—The Canadian Government will establish a Central Resources Institute at an initial cost of $600,000 for buildings and laboratory equipment. The general idea is that the institute should combine the functions of the Bureau of Standards at Washington, D. C., also the duties of the Mellon Institute at Pittsburgh, Penn.

PORT ARTHUR—J. J. Carrick, 13 Cumberland St., N., will build a pulp and paper plant. Estimated cost, $7,500,000. H. S. Ferguson, 200 5th Ave., New York City, engineer, preparing plans.

Quebec

MONTREAL—The Commissioners of the schools of Coteau and St. Pierre are in the market for equipment for their new chemical laboratory, manual training and art departments. D. I. Spence, 246 Beaver Hall, architect.

QUEBEC—Price Bros. Co., Ltd., 56 St. Peter St., will build a new pulp mill. Estimated cost, $1,000,000.

QUEBEC—The Valcartier Lumber & Pulp Co., Ltd., will receive bids in March for the construction of a pulp mill. Estimated cost, $350,000.

Coming Meetings and Events

THE AMERICAN CHEMICAL SOCIETY will hold a meeting in Buffalo, April 7 to 11.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its annual meeting in New York City from April 3 to 5.

THE CANADIAN MINING INSTITUTE will hold its twenty-first annual meeting on March 5 to 7, 1919.

THE NATIONAL FOREIGN TRADE COUNCIL will hold its sixth National Foreign Trade Council at the Congress Hotel, Chicago, Ill., on Thursday, Friday and Saturday, April 24, 25 and 26, 1919.

THE SOCIETY OF INDUSTRIAL ENGINEERS plans a national conference at New York March 18-21 at the Hotel McAlpin, at which there will be a discussion of labor by both employers and labor leaders. Internal plant organization and also the elimination of fatigue will be other leading topics.

Industrial Notes

THE ALL-RUSSIAN CENTRAL UNION OF COOPERATIVE SOCIETIES invites American manufacturers and producers to send price lists and catalogs in duplicate to the headquarters of the Union, Liebes Building, 167 Post St., San Francisco, Calif. It is stated that the All-Russian Central Union represents the bulk of Russia's buying power.

THE WELLMAN-SEAVER-MORGAN CO., Cleveland, Ohio, held its annual meeting of stockholders on Feb. 18 and re-elected the retiring board of directors as follows: Edwin S. Church, F. E. Borton, W. H. Cowell, F. B. Richards, S. T. Wellman, E. H. Whitlock of Cleveland, S. H. Pitkin, Francis Seiberling and F. A. Seiberling of Akron, O. The directors have elected the following officers: Edwin S. Church, president and general manager; S. H. Pitkin, vice-president; Geo. W. Burrell, second vice-president; and W. H. Cowell, secretary and treasurer. Mr. G. W. Burrell, who was elected second vice-president, has been in the continuous employ of the company for twenty-one years. He will have entire charge of the company's works both at Cleveland and Akron.

For the purpose of aiding American manufacturers in expanding export trade to the twelve nations of Central Europe and Asia Minor which recently declared their independence and formed an alliance known as the Mid-European Union, and to expedite the delivery to these countries of such materials as is needed by them, a bureau of information and education has been created with offices in the Union headquarters, McLachlen Building, 10th and G Streets, N. W., Washington, D. C. The countries which have pledged themselves to the Union of independence through official representatives in this country are: Czecho-Slovaks, Poles, Jugoslavs, Ukrainians, Uhro-Rusins, Lithuanians, Rumanians and Italian Irredentists, Unredeemed Greeks, Albanians, Zionists and Armenians. The following are the representatives in this country: T. G. Masaryk, (for the Czecho-Slovaks), T. M. Helinski, (for the Poles), Dr. Hinko Hinkovic (for the Jugoslavs), Nicholas Ceglinsky (for the Ukrainians), Gregory Ignatius Zsatkovich (for the Uhro-Rusins), Thomas Norus Narusevicius (for the Lithuanians), Capt. Vasile Stoica (for the Rumanians), Charles J. Tomazolli (for the Italian Irredentists), Christos Vassilakaki (for the Unredeemed Greeks), Christo A. Dako (for the Albanians), Ittamar Ben-Avi of Jerusalem (for the Zionists), G. Pasdermadjian (for the Armenians). The bureau announces that the Central European countries are in immediate need of materials and commodities of every description and it is the intention to gather all available information valuable to the manufacturers of this country both as to the character of goods desired and as to specifications. In other words, the bureau will act in an advisory capacity to both the purchaser and seller. Mr. J. Nichols is assisting in directing the affairs of the bureau.

Manufacturers' Catalogs

THE MILWAUKEE RELIANCE BOILER WORKS, Milwaukee, Wis., calls attention to Bull. No. 101, on Sharp-Bassett gas producers. This booklet describes and illustrates combined steam and gas generators, improved gas producer, gives a curve showing the full consumption of a modern producer gas engine at various loads, comparative costs of power of various types of engines and producer gas for power and fuel.

THE SHAWINIGAN ELECTRIC-METALS CO., Ltd., Montreal, Canada, has issued an attractive booklet, No. 2, dated Dec. 2, 1918, entitled "Shawinigan Magnesium," which contains 36 pages on foundry practice in using magnesium, physical properties, chemical properties, chemical uses, alloys, table of comparative costs, commercial forms, packing and quality.

THE WESTINGHOUSE ELECTRIC & MFG. Co. and associated companies have issued the annual catalog of electrical supplies containing a list of all apparatus manufactured by the company or obtainable through its district offices and agent-jobbers. The catalog, comprising 1264 pages, contains a complete cross index and supply number index.

THE SCIENTIFIC MATERIALS CO., Pittsburgh, Pa., has just issued a "Blue Book" of scientific laboratory equipment. The distinguishing feature of this catalog is that not a single item listed is "Made in Germany." This is noteworthy when it is considered that the catalog comprises over 650 pages and contains a complete list of apparatus, equipment and chemicals.

THE DEISTER CONCENTRATOR CO., Fort Wayne, Ind.: Bull. No. 3 illustrates and describes in 24 pages Deister-Overstrom Diagonal Deck Concentrating Tables.

THE GREEN FUEL ECONOMIZER CO., Beacon, N. Y., has just received an attractive booklet from the press, Bulletin 151, on "Green's Economizers." This 64-page booklet deals with the first economizer, heat of fuel present in flue gases, economizer practice, secondary advantages, special uses, photographs of installations, steam tables and dimensions.

THE WESTINGHOUSE ELECTRIC & MANUFACTURING CO., East Pittsburgh, Pa.: Catalog 33, entitled Westinghouse Alternating-Current Motors, describes and illustrates in 80 pages classification and selection of a-c motors, squirrel-cage induction motors, headstock motor equipments for woodworking lathes, wound-rotor induction motors, elevator motors, type AR, single-phase, constant speed motors and also synchronous motors.

HAMILTON & HANSELL, INC., New York, has issued a booklet on the Rennerfelt electric arc furnace which illustrates and describes this furnace.

Stocks and Bonds

Closing Bid and Asked Quotations Feb. 26, on N. Y. Stock Exchange

CHEMICAL COMPANIES

	Bid	Ask		Bid	Ask
Am. Ag. Ch.,..	102	102½	Mat. Al. Wk..	34	44
do. pf.....	98½	99½	Ten. C. & C..	13	13½
Barrett Co...	118	119½	Un. Dyewood	50	61
do. pf.....	110½	113	do. pf.....	90	....
Gen. Chem...	165	173	Va.-Car. Ch..	54½	55
do. pf.....	102½	103½	do. pf.....	112	113
Int. Ag. Ch..	14	15			
do. pf.....	58	58½			

Bonds

Am. Ag. Ch., 1st cv. 5s, '28.....	99½	100½
Am. Ag. Ch., cv. db. 5s, '24.....	102	103
Int. Ag. Ch., 1 mtg. & col. tr. 5s, '32.....	79½	80
Va.-Car. Ch., 1 mtg. 5s, '23.....	95½	96
Va.-Car. Ch., cv. db. 6s, '24.....	100½	102

PETROLEUM COMPANIES

	Bid	Ask		Bid	Ask
Asso. Oil Co..	71½	74	P-A Pet & Tr	79½	79½
Cal. Pet.....	26½	27	do. pf.....	135	140
do. pf.....	72	72½	Pierce Oil....	17½	17½
Col. G. & E..	45½	45½	Royal Dutch.	94½	95½
Mex. Pet.....	177	177½	Sinclair O & R	36	36½
do. pf.....	105	109	Texas Co.....	193	193½
Ohio Cit. Gas.	37½	37½	Tex. Pac. Ld. Tr.....	240	290
do. pf.....	....	....	Tidewater Oil.	221	225
Ohio Fuel S..	44	45			
Okla. P. & W.	8½	8½			

Bonds

Columbia Gas & Electric, 1 5s, '27.....	81½	82½
Col. G. & El., std. 1 5s, '27.....	81½	82½
Pan-Am. Pet. & Tr. 1 6s, '19-'27.....	130	....
Pierce Oil, cv. db. 6s, '24.....	92	92½
Pierce Oil, cv. 5% Notes, '20.....	101	101½
Sin. O. & R. 1 ln. 7s, '20, with stk. war.....	99½	99½
Sin. O. & R. 1 ln. 7s, '20 without stk. war..	96	96½
Texas Co., db. 6s, '31.....	101½	102
Union Oil of Cal. 1 5s, '31.....	93	94
United Fuel Gas 1 mtg. 6s, ser. A, '36....	95½	97

IRON AND STEEL SECURITIES

	Bid	Ask		Bid	Ask
Am. St. F.....	81½	82	Pitts. Stl. pf.	90	98
Beth. Steel...	63½	64½	Rep. Iron & Steel.....	77½	77½
do. class B.	64½	64½	do. pf.....	101½	102½
do. pf., 8%.	104½	104½	Sloss Sheff. I. & S.....	50½	50½
do. pf., 7%.	92	100	do. pf.....	86	....
Central Fdry.	18	21	Superior Steel	36	36½
do. pf.....	34	39	do. 1 pf....	95	99
Col. F. & I...	38	38½	Trans. & W. Steel.....	38½	40
do. pf.....	99	....	Un. Alloy St..	41½	42
Cruc. Steel...	60	60½	U.S.C.I.P.&F.	19	19½
do. pf.....	90½	91½	do. pf.....	53	55
Great No. Ore	39½	39½	U. S. Steel...	95½	95½
Gulf Sta. Steel	52	53	do. pf.....	114	114½
do. 1 pf....	94	99	Va. Coal, I&C	54	60
Lack. Steel...	66½	67			
Mid. St. & Ord	42½	42½			
Nova Scotia Steel.....	49	....			

Bonds

Beth. Steel, 1 ext. gtd. S.F. 5s, '26.....	95½	96½
Beth. Steel, 1 ln. ref. 5s, Ser. A, '42.....	88½	89
Beth. Steel, P. M. & I. S. F. 5s, '36.....	81	82
Buff. & Susq. Iron, 1 S. F. 5s, '32.....	91	96
Buff. & Susq. Iron, deb. 5s, '27.....	....	....
Cent. Found. 1 mtg. S. F. 6s, '21.....	80	82
Col. F. & I., gn. S. F. 5s, '43.....	86½	90
Ill. Steel, db. 4½s, '40.....	84½	85½
Ind. Steel, 1 mtg. gtd. 5s, '52.....	97	98½
Lack. Steel, 1 5s, '23.....	96½	97½
Lack. Stl., 1 con. mtg. cv. 5s, Ser. A, '50.	86½	87
Mid. St. & Ord., clt. cv. S. F. 5s, '36.....	86½	86½
Nat. Tube, 1 mtg. gtd. 5s, '52.....	96	98
Rep. I. & S., S. F. mtg. 5s, '40.....	95	95½
Tenn. C. & I. R.R., gn. 5s, '51.....	91½	95½
U. S. Steel, S. F. 5s, '63.....	100½	100½
Va. C., I. & C., 1 5s, '49.....	87	89½